VEGETABLE CROPS PRODUCTION GUIDE

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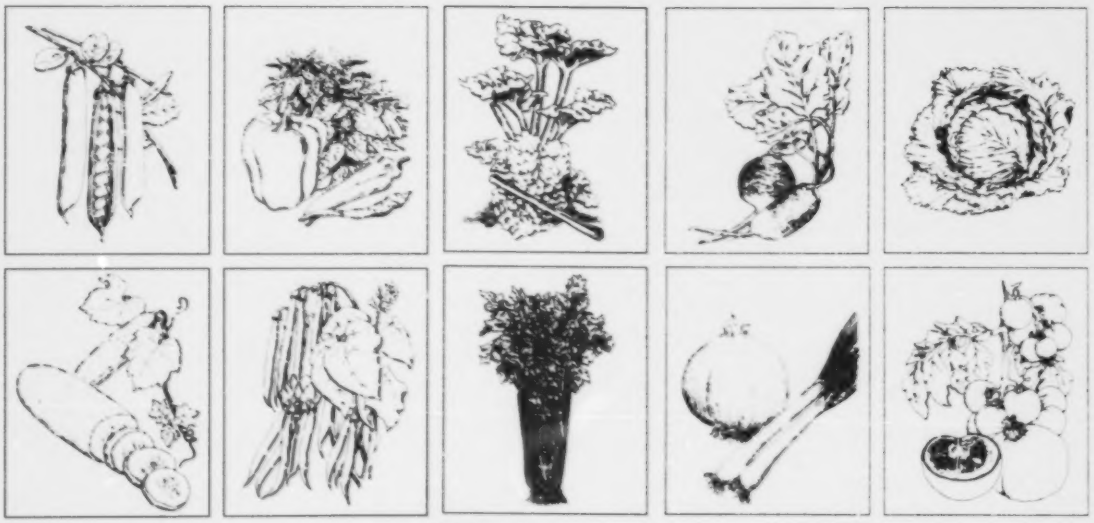
for the ATLANTIC PROVINCES



Prepared by the
ADVISORY COMMITTEE ON
VEGETABLE CROPS

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For additional information regarding vegetable crop production, refer to APASCC. Publication #1400A—Guide To Cultivar Selection and Chemical Pest Control.

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Vegetable Crops Publication 1400A
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I FOREWORD

This publication has been compiled by members of the Atlantic Committee on Crops, directed by the Advisory Committee on Vegetable Crops with coordinating work by the following editorial committee:

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This Vegetable Production Guide contains accepted techniques for vegetable production and management in Atlantic Canada on mineral soils. Contributions were also made by members of the APASCC Advisory Committees on Soil Fertility, Agrometeorology, Marketing, Structures and Equipment, and Economics, Education and Extension.

Bibliographic information identified with each topic or crop discussed is suggested as a source of additional or complementary information. However, because they may not reflect cropping experience within the Atlantic Region, these references may suggest production practices or techniques not suitable to this area. For clarification contact your Provincial Vegetable Specialist.

Since publication is at intervals of several years, specific recommendations may change before the next issue appears. In view of this, care should be taken to check on accepted production practices from time to time with the nearest Department of Agriculture office. For specific details on vegetable production on muck or peat soils contact one of the above listed persons.

Specific cultivar and pesticide recommendations are found in APASCC Publication 1400 A "Guide to Cultivar Selection and Chemical Pest Control" - an annual or biannual supplement to this book.

More detailed, agricultural production and management information is contained in publications, available from your local Agricultural office.

II Farm Records and Crop Budgets

The most important task of the farm manager is to make decisions and carry them out. Decisions must be made about current operations and future plans, and involve a choice between one or more alternatives. Choosing the most profitable alternatives is the primary task of the farm business manager to ensure good financial health of the farm business.

The manager must obtain and analyze information needed to make a decision and carry it out to the best advantage for the business.

The basic tool for farm business decision-making is a good set of farm records (financial and production), accounts, technical information, and budgets that provide all the necessary information for the manager.

So why keep farm records?

(I) Provides the operator with a history of past performance of the farm for the period in which records were kept. (1) Shows the farmer where he stands financially at any time. (2) Permits him to appraise his progress between inventory dates and over the period in which records were kept. (3) Provides a record of receipts, expenditures, crop yields, and so on.

(II) Provides an aid in the management of current farm operations. (1) How well does the business conform to production plans as set up in the budget? This applies to financial plans as well as physical and technological effects. (2) Helps in detecting unsatisfactory performances.

(III) Provides the basic information needed for a budget. (1) Farm records furnish the necessary information on past crop yields, and actual amounts of receipts and expenses.

(2) To be useful, a budget must reflect the productive potentialities of the farm.

(IV) Provides the financial data necessary in computing the farmer's income tax payable.

(V) Provides the basic information necessary for a sound credit policy.

Time spent in planning the record keeping system is essential. Remember the system must give you the answers you need when you need them. If you want to know gross earnings from the farm and the total costs of inputs, then you set up very simple records. But the answers will be very general. You may want to determine the profitability of each crop in each month in each market, and that requires a more specific type of record keeping — both types have specific purposes.

It is important to state that this type of information is not an end in itself. These items provide the means for assessing the past performance, identifying business or production problems, and provide the building blocks for future planning. Keeping records solely for the purpose of satisfying the "tax-man" is no longer sufficient to ensure a healthy, profitable farm business.

Farm Financial Records:

There are five essential parts of a good farm financial record system: (1) inventories; (2) expense records; (3) receipt records; (4) production records; and (5) summary of the year's business by the generation of a Farm Balance Sheet and an Income and Expense Statement or Profit and Loss Statement.

The basic minimum is a general account for the whole business with enough detail to be able to compile a financial summary in the form of a "balance sheet" and an operation statement or a "profit & loss" statement. These two statements describe the farm business and answer the question "What is the Situation?" They provide the basic information needed to diagnose the whole business or answer the question "What is healthy and what is wrong with the business?"

In order to answer some of the questions above, a more detailed account should be kept on each enterprise or crop to determine which crops or enterprises are profitable and which are marginal or loss generators.

Fundamentally an enterprise account is the same as a general account. Inventories must be taken and records of expenses and receipts specific to that enterprise must be kept. The greatest difficulty in enterprise accounting lies in the allocation of joint and overhead costs such as building costs, machinery costs, labour or taxes, etc. The farm operator must make a valid decision as to what preparation of joint costs are charged against each enterprise.

Farm Production Records

A set of good farm records is not complete without a set of production records. Recording of the quantities and cost of inputs (seed, fertilizer, chemicals, etc.), seeding and harvesting dates, field and marketable yields, soil test results and listing of analysis and rates of fertilizer used, and noting of abnormal circumstances such as disease, drought, frost, etc., are extremely important and useful in analysis and future planning of a farm operation.

Crop production records are important in vegetable production to assist the grower in evaluating many important management factors as identified below.

Pesticides

Pesticides can cause problems in contamination and residues if proper planning is not conducted. Herbicide residues can be avoided by using weak control chemicals which do not cause carry over to subsequent crops. Registered insect and disease control chemicals should be selected that have few or zero days between application and safe harvest. Recording the location, date and time of application of these chemicals can be invaluable in planning future crop production.

Cultivars

Fresh vegetables early in the season can attract customers to a U-pick and selecting the right cultivars can lengthen the market season. Recording the cultivar and its performance under such aids as row covers or mulches can improve the managers ability to select and schedule the most profitable crop. Such information combined with a record of planting and harvest dates can assist in planning successive plantings of the main season crop cultivars.

Populations

Standardization of row spacing is particularly important when several crops are grown on the vegetable farm. This may require growing some crops at row spacings different than the optimum recommended for that crop. Ease of harvesting should also be a consideration in selecting the best row spacing for a particular crop. Arriving at the "best suited" population for particular crops in the farms production system is most easily accomplished with reference to good production records.

Record Keeping System

Farm account books are available from the Provincial Departments of Agriculture. These books have their own introduction and instructions and are designed to do a certain job. In many cases they are ample but more specific information may be required if you have developed additional enterprise accounts.

Provincial Departments of Agriculture also provide very detailed soil and crop record books which enable the recording of crop production inputs, soil test values, tissue test results and other information on a particular field.

There are also several sophisticated but practical systems of electronic bookkeeping available to farmers. These systems "humanize" the laborious task of keeping detailed farm financial and production records. The major weakness in all such systems, to date, is that the financial and production records are not integrated. Even the best may require manual transfer of information from financial to production records to determine cost or return per unit of crop output.

Regardless of the system selected: plan a workable system: who, does what, when and how. Be punctual do not let the record keeping pile up. Do not forget to make entries, for the record will have little meaning.

Finally, the analysis of records is often the most overlooked aspect. Many people keep records, summarize them but then do not analyze them. This analysis can be most beneficial if a unbiased second party is involved such as an extension worker or agricultural accountant. It is essential that producers look critically at these figures and make the correct decision for planning future budgets and crop plans.

Crop Production Budgets

A budget is simply a convenient tool whereby the use of farm resources is planned and the probable receipts and expenses are estimated on paper before any actual steps are taken. It allows the use of economic principles. Estimating the effect of each alternative will allow the manager to choose the one which will more nearly achieve a given objective.

An effective budget is a plan of the farmer's time, land, equipment and other resources for a specific period of time, usually one year. Budgeting is one of the best known methods of selecting the most profitable crop within the whole vegetable farm enterprise. Budgeting leads the farm manager to consider the income as a whole, not in parts. The budget is valuable as a guide for carrying out any changes decided upon later. It is a valuable guide to the details of crop production economics (farm management) after all major plans have been decided upon and put into practice. For example: (1) plans can be made to meet expenses listed in the budget, (2) a labor program can be planned to obtain economy and efficiency, (3) more accurate estimates of seed, fertilizer, sprays, equipment and other supplies can be made, (4) credit can sometimes be improved by having a budget.

With adequate records and budgets you can compare your cost of production with others. If your production costs are higher than others, then you must find out why. On the other hand if your costs are lower you are likely in a much more competitive position to enter or remain in a particular market.

Crop production budgets are available from the Farm Management specialists within the Provincial Departments of Agriculture. Many of these are now computerized and provide a quick and effective means for the farmer to evaluate crop production.

The most important step in the production of any crop is to determine costs of production of various management systems and subsequently, establish if a profit can be made from a particular market. That is establish a cost of production budget.

Generally, costs of production are divided into two categories — fixed costs and variable costs. Fixed costs are a characteristic of the individual farm enterprise and are those costs most readily controlled by the operator. Variable costs are more characteristic of the generally accepted production inputs required to achieve maximum marketable yield. Although this group of costs is also under control of the individual operator, he has less flexibility in controlling or managing these expenses than the fixed costs.

Farm analysis, planning and budgeting

The budget, therefore, is the planning phase in farming. It is a systematic and orderly approach to farm planning. It is a formal plan written down on paper. Many farmers develop plans in their head in a general way and work out the details as they go along. This is still budgeting and planning. However, definite long-term budgets are needed to provide for short-run adjustments in the year ahead.

A good farm plan should provide a sound land use and cropping system. A choice of crops (enterprises) that fit together well, provide a good labor distribution and give proper balance in the most efficient use of other resources. Sufficient volume to permit the efficient use of labor, power, machinery, and other facilities. Adequate labor-saving equipment, farmstead arrangement and building design consistent with the type and volume of business to be done. Adoption of practices that will give the most profitable crop yields. Enough flexibility in farm organization to facilitate adjustments to changing economic conditions.

Within the whole farm plan the crop mix (plan) should yield the maximum contribution to net farm income over a long period of time. Maintain soil fertility. Make possible the most efficient use of such cost elements as labor and power and should permit the spreading of investments in machinery and equipment over as many units of output as possible. In summary, the crop plan on any vegetable farm should be such as to optimize cash flow.

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III Climate and Vegetable Production

The Atlantic region provides a variety of growing conditions. Coastal areas have a long but cool growing season, while sheltered inland valleys have a shorter but much warmer growing season. Areas which have warm summers can still experience very cold winters which cause problems with survival of perennial crops. The temperature at Fredericton, New Brunswick, ranges from an extreme maximum of 39° C to an extreme minimum of −39° C whereas at the coastal location of Yarmouth, Nova Scotia, the extreme maximum is 30° C and the extreme minimum is −20° C, a much narrower temperature range. Such variation in climate requires crop selection and management practices suited to the climate and soil conditions of the location.

The growing season in the Atlantic region is characterized by a cool wet spring, a warm summer with ample rainfall, but with occasional dry periods, and a cool wet autumn. The cool spring with generally high rainfall combined with heavy imperfectly drained soils, common in the region, creates field trafficability problems which delay spring field work and seeding. Delayed seeding means the crop is losing the benefit of any early warm spring days. A late-planted crop risks not reaching maturity or its maximum yield potential before fall frosts threaten. Late seeding also delays harvest to a time when high rainfall can once again cause field trafficability problems.

The growing season for frost sensitive crops is determined by the last spring frost and first fall frost. The frost-free period varies a great deal depending upon latitude, elevation, topography, and proximity to large water bodies. The frost-free period in Atlantic Canada is generally adequate for many vegetable crops; however, heat-loving, long season crops, such as tomatoes are limited to a few locations. Although coastal locations have longer frost-free periods, they do not have the high temperatures required for the rapid growth and maturity of warm season crops. The use of plastic mulches and tunnels can alter the microclimate of the crop to provide sufficient heat for crops such as peppers, melon and eggplant to reach maturity.

Reduction of frost risk and optimization of heat can be obtained by careful site selection, variety selection and management. Consideration of long-term climatic averages and extremes is essential for the successful introduction of new crops, new varieties, new hybrids, and the expansion of production into new areas.

The Climate of Atlantic Canada

Weather and climate dictate what crops can be grown in a region and are mainly responsible for the yearly variation of yields. The difference between weather and climate is that the former is concerned with rain, sun, heat, cold, or winds which happen now, while the climate is the long term average describing what generally happens.

There are four factors which determine the climate of a place;

- position on the globe,
- wind systems,
- the ratio of water to land, and
- topography.

Despite the maritime location of the Atlantic provinces, the climate is a modified continental type. A continental climate is characterized by a wide range of temperature, whereas, a maritime climate is characterized by a reduced temperature range because the ocean supplies heat in winter and provides cooling in summer. Areas near the coast have milder winters and cooler summers, with a longer frost-free period than inland locations. The advantage of a prolonged season however, is offset by the cooler temperatures and fewer heat units available for plant growth.

The wind direction and the relationship of land to water is a major factor determining climatic differences within the region. The southern coasts of New Brunswick, Nova Scotia, and Newfoundland have the highest annual precipitation in Atlantic Canada due to south-easterly storm winds blowing moisture-laden air onshore. In contrast, the Northumberland coasts of New Brunswick and Nova Scotia, all of Prince Edward Island, and northern Newfoundland are in a "rain shadow". This means that south-easterly storm winds have already dropped most of their precipitation by the time they reach these areas and precipitation amounts are reduced.

Coast waters differ in the influence they have on the climate of adjoining land. The warm waters of the Gulf of St. Lawrence and especially the Northumberland Strait, do not provide as much cooling in summer as do the cool waters of the Atlantic. In winter, the Gulf waters are frozen and do not provide the warming the Atlantic Ocean does. For this reason, the Gulf waters are less effective in moderating the climate of Prince Edward Island, eastern New Brunswick, northern Nova Scotia, and western Newfoundland. The greatest moderating effect of the Atlantic is seen in southeastern Newfoundland, western Nova Scotia, and southern New Brunswick. The cold Labrador current, curving around Newfoundland's Avalon peninsula makes this the coolest part of the province in summer and the mildest in winter. This same, although weakened current has a similar but reduced effect on the southeast coast of Nova Scotia.

Climatic Normals

A long period of weather observations is necessary to establish the normal climatic pattern for a given region. The term "Climate Normals" is used to describe the average data for a 30 year period.

Climatic normals represent the average of widely varied yearly values which occurred over the 30-year period. When evaluating crop performance in any given year, that year's weather should be compared with the long term climatic normals to judge whether the season and crop performance were normal.

The accompanying maps on frost and degree days are drawn from climatic normals provided by Environment Canada for 233 stations throughout Atlantic Canada.

Frost

Frost normals can vary significantly within short distances due to the effect of sloping terrain or large bodies of water. It is important to have a long period of record when mapping this parameter. The average frost-free period ranges from less than 70 days in central Newfoundland to 170 days in some Maritime coastal areas (Map 1, 1a).

The average is sometimes not adequate for planning, because often it is the extreme event which can be disastrous. For this reason, extremes for the entire period of record should be examined before an important decision is made.

Degree-days (Heat-Units)

Temperature affects plant processes mainly by controlling the rate of growth. The concept of growing degree-days, or heat units, is based on the assumption that plant growth is related directly to the average temperature. There are however, certain minimum or "threshold" temperatures below which plants do not grow. For perennial plant growth, a threshold temperature of 5° C is commonly used, while for tender heat loving plants, such as tomatoes and beans, a base temperature of 10° C is more appropriate.

To compute degree-days for a particular day, calculate the average of the maximum and minimum temperature for the day. Then subtract the base temperature from the average temperature.

Example:
Maximum Temperature = 24° C
Minimum Temperature = 16° C
Average Temperature = 24 + 16 = 40/2 = 20° C
Degree-days above 5° C = 20 − 5 = 15
Degree-days above 10° C = 20 − 10 = 10

If the daily average temperature is below the base temperature, the degree-day value is zero. Negative values are not used because crop development is not reversed. When using degree-days it is important to know what base temperature and also what temperature scale has been used.

Average Annual Degree-days Above 5° C

The largest heat unit totals in the Maritimes are found in the Annapolis Valley of Nova Scotia, the Grand Lake area of New Brunswick, and the coastal area along the Northumberland Strait. Cold Atlantic waters reduce degree-day totals along the south and eastern shore of Nova Scotia and along the Bay of Fundy. This influence decreases with distance inland. The warm waters of the Northumberland Strait keep the adjacent Coastal areas warm.

The northeastern part of Newfoundland, including the northern part of the Avalon peninsula, has the most heat units in the province. This area is sheltered from the prevailing south-westerly winds. A narrow coastal strip from Corner Brook to Stephenville also has high heat unit totals, in this case due to the influence of the warm waters of the Gulf of St. Lawrence. The high elevations of the Long Range Mountains have the lowest heat unit totals. Most coastal areas have low heat units.

Degree-day normals are prepared by adding together the degree-days for each day of the month, for each of 30 years, then the average monthly degree-day total is calculated (Degree days above 5° C are depicted in Maps 2, 2a). Degree-day information is used to indicate how much heat is available in an area for crop production. By selecting crops or varieties with a heat requirement matched to the location, a successful harvest is more likely.

Corn heat units are widely used for corn hybrid maturity ratings. They differ from degree-days described above, in that the maximum and minimum temperature are used separately to assess the contribution to corn development. High maximum temperatures are preferred and are given more weight than cooler minima, which reflects the heat loving nature of the crop. "Heat units for Corn in the Maritime Provinces" (Pub. No. ACA 79-1) is a publication that provides detailed information and is available at local agricultural offices.

The Farm Level Climate

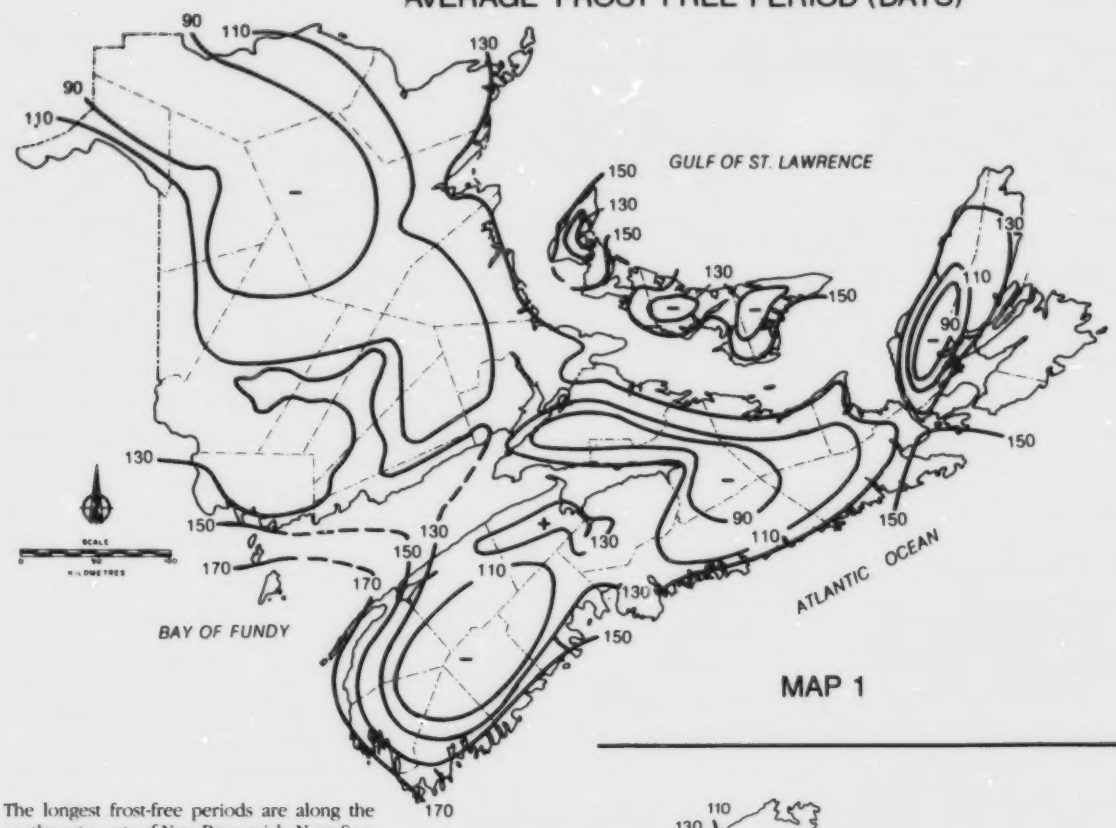
The climate at the farm level can often be different from the climate of the surrounding area. Local features all interact to produce a climate unique to the location. Knowledge of these factors, when used with the values indicated in the atlas, should provide a better indication of what to expect on the farm in the future. The factors that influence the climate at the farm level are;

- topography,
- slope and aspect,
- large water bodies,
- elevation, and
- wind.

Topography

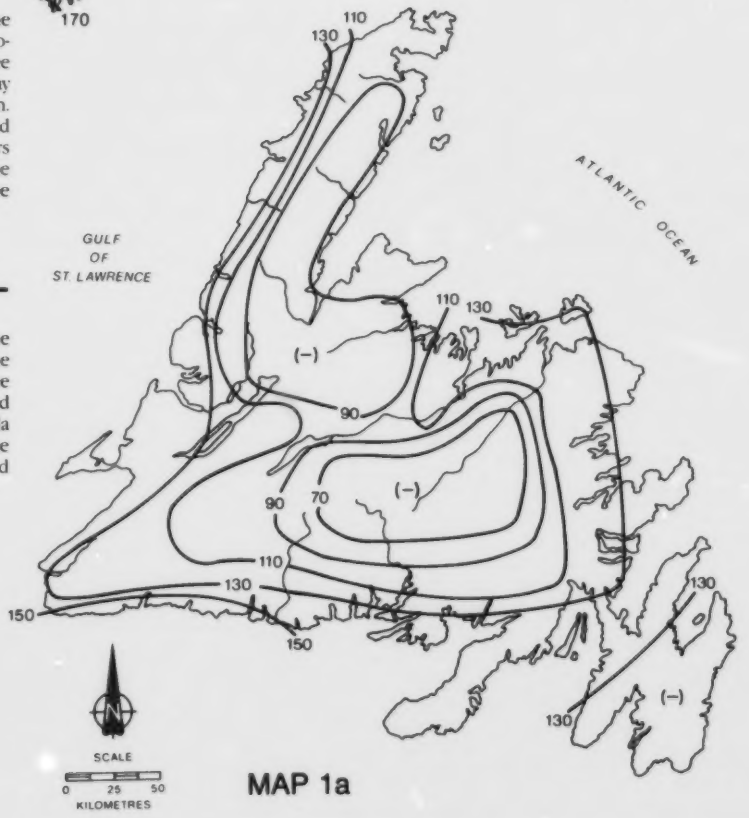
Topography has a marked effect on the incidence of frost. After sunset the ground cools rapidly and its temperature soon falls below that of air in contact with it. The surface layer of air becomes cooler and heavier. Over sloping ground this cooled surface air tends to drain to lower levels and to collect in depressions or hollows. In a frost hollow, drainage of cold air into the depression results in frost much later in the spring and earlier in the autumn than at surrounding locations. Hillside locations will, on the

AVERAGE FROST FREE PERIOD (DAYS)



MAP 1

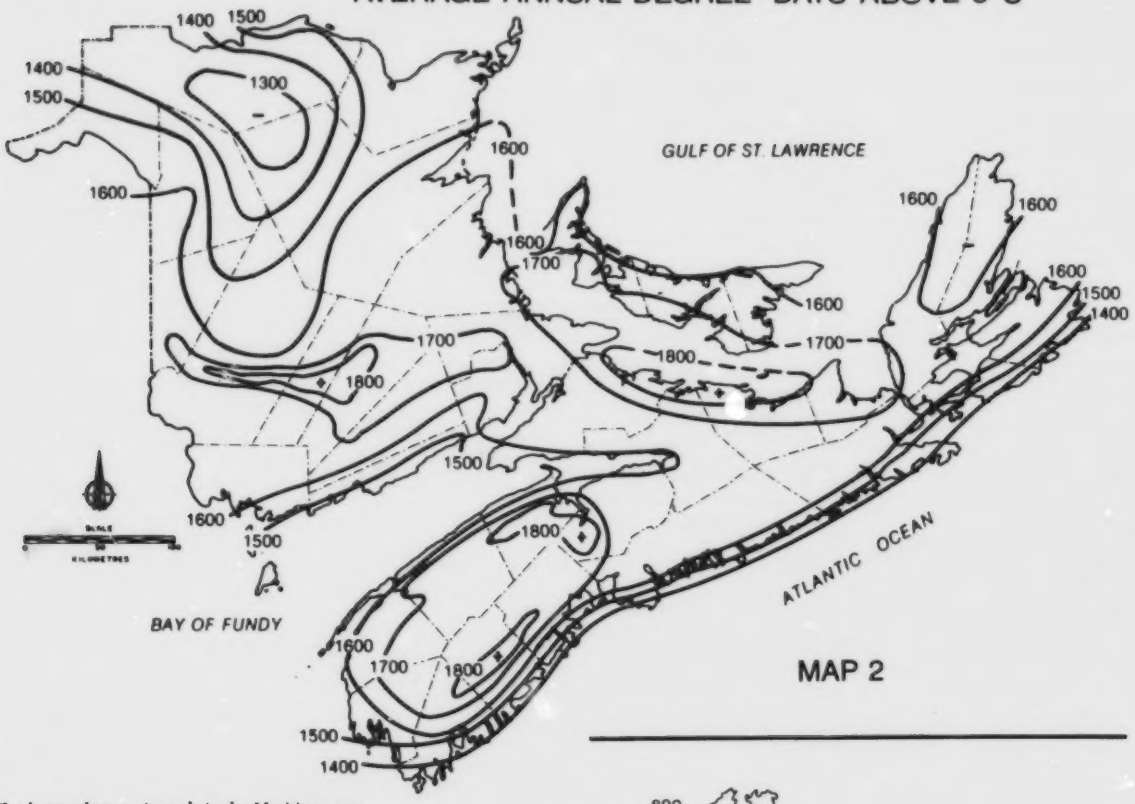
The longest frost-free periods are along the southwest coasts of New Brunswick, Nova Scotia and Prince Edward Island. The frost-free period decreases rapidly with distance away from the moderating influence of the ocean. The coastal area along the Northumberland Strait has a frost-free period of about 130 days very near the water. Inland areas and the higher elevations have the shortest frost-free periods.



MAP 1a

The longest frost-free period is along the south coast from Burgeo to Cape Ray. The next shortest frost-free period is along the south, west and east coasts. Inland areas and the eastern part of the Northern Peninsula have the next shortest frost-free period. The interior of the province has a frost-free period of only 70 days.

AVERAGE ANNUAL DEGREE-DAYS ABOVE 5°C



MAP 2

The largest heat unit totals in the Maritimes are found in the Annapolis Valley of Nova Scotia, the Grand Lake area of New Brunswick, and the coastal area along the Northumberland Strait. Cold Atlantic waters reduce degree-day totals along the south and eastern shore of Nova Scotia and along the Bay of Fundy. This influence decreases with distance inland. The warm waters of the Northumberland Strait keep the adjacent Coastal areas warm.

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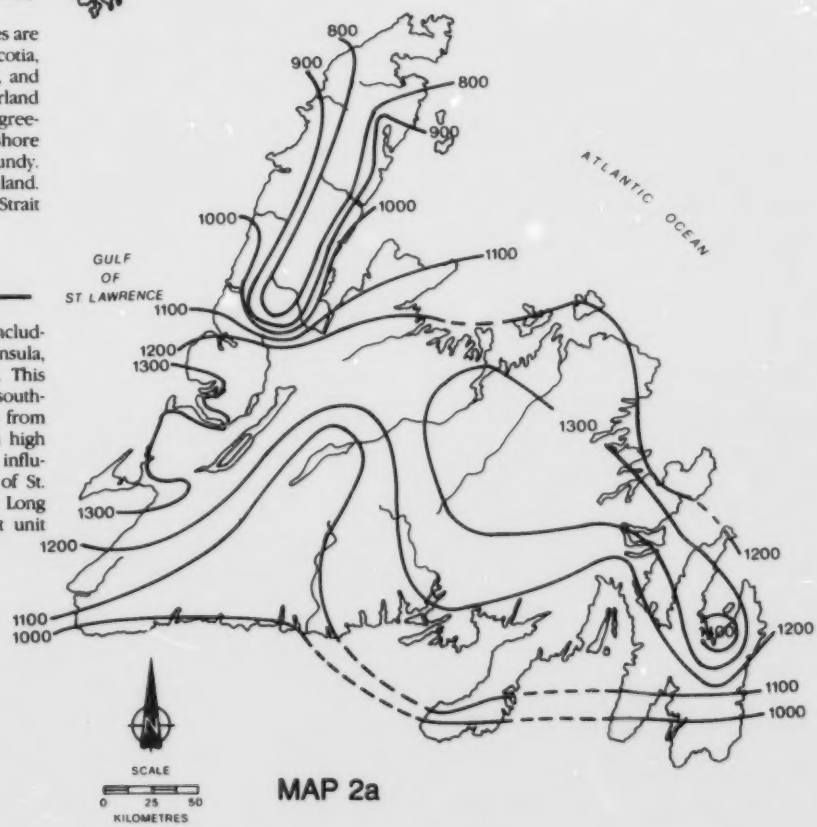

MAP 2a

average, tend to have longer frost-free periods than neighbouring stations on lower ground or in a valley.

Night winds influence temperature differences between hillsides and valleys on clear nights. The best conditions for cold air drainage are found when there is no general air movement. Even a light wind will serve to mix the relatively warm air above with the thin layer of surface air which has cooled through contact with the ground. Moderate winds will prevent differences in temperature between hillsides and valleys.

Slope and Aspect

Slope plays a major role in farm level climate. Valley bottoms experience colder nighttime temperatures and usually warmer daytime maxima than either midslopes or hilltops. The total heat units over an entire growing season are usually highest on midslopes, less on hilltops, and lowest in valley bottoms. This order is much more pronounced when heat units are accumulated between frost dates. Cold air running down the slopes and pooling in valley bottoms causes later spring and earlier fall frost dates. Hilltops usually have a shorter frost-free period than midslopes because of greater exposure to radiative loss to the atmosphere at night. Exposed hilltops have slightly cooler maximum temperatures than midslopes. In winter, midslopes accumulate more snow than hilltops, particularly on the lee side of the prevailing winds. The influence of aspect can change these relationships.

Aspect, or orientation to the direction of the sun, has two roles in crop production. In winter, south facing slopes produce warmer conditions that may result in harmful freezing and thawing cycles. Snow melt accounts for less depth and denser snow packs on south slopes. This results in a decrease in the protective value of the snow which may be important to overwintering perennial crops. In contrast, the growing season conditions are more favourable on south slopes. Warm south and west facing slopes provide more heat units and higher soil temperatures early in the season. Spring soil moisture conditions are generally wet, depending upon soil type. In this instance, south slopes have higher evaporative losses and field trafficability is earlier as a result. Droughty soils may be accentuated on south slopes.

Influence of Large Water Bodies

Large water bodies modify the local climate by warming in winter (if unfrozen) and cooling in summer. This effect is most pronounced near the coast but may extend inland several kilometers depending on elevation, topography, and prevailing winds.

Water bodies may also extend the frost-free period. Near the ocean at night, land breeze circulations draw cool air away from the land areas. Inland, large lakes and rivers heat the air which drains at night to the valley floor. Lakes and rivers also yield large amounts of moisture to the air. When this moist air cools, fog forms. All of these processes delay frost and extend the frost-free season.

Elevation

Elevation has the most influence on precipitation totals and heat unit accumulation. Generally, higher elevations have lower heat unit accumulation. Precipitation on the other hand, increases with elevation due to orographic lifting. When warm moist air masses are forced upwards by rising land, the air mass cools and the moisture is precipitated out as rain or snow. The proportion of precipitation that falls as snow also increases with higher elevation.

Wind

Exposure to high winds is usually detrimental to crop production, and many studies indicate better yields in protected or sheltered areas. Two suggested reasons for this are; desiccation of plants from high evapotranspiration losses, and physical damage to plants directly from the wind. The establishment of some barrier to the wind on the prevailing wind side may be required to improve the situation. If additional winter snow cover is desirable, wind breaks will increase this cover. In Atlantic Canada, summer winds are usually from the south and southwest while winter winds are from the west and northwest.

Water

The crop water balance is of great importance to agriculture. Top agricultural productivity depends not only on optimum temperatures but also on optimum water supply. Too much or too little water can be disastrous. Modifying the natural water regime in some way or other is a common management practice. Soil characteristics are important in the crop water balance and can be improved by increasing organic matter, for instance. Over the short term however, soil characteristics remain constant, whereas climatic factors such as rainfall and evaporation vary widely during the season, and from year to year.

Water Excess

The two major problems caused by excess water are i) poor field trafficability, and ii) poor or harmful growing conditions.

Wet soils are slower warming up in the spring because the sun's energy is used to evaporate water instead of warming the soil. If there is trash or mulch on the field, it will keep the soils cooler and wetter. Plowed land dries quicker because is has more surface area for evaporation and the upturned clods create wind turbulence which helps speed drying. Subsurface drainage has similar beneficial effects.

Excess water due either to rain or over-irrigation will cause delayed growth and maturity, and may encourage the development of disease problems, leaching of nitrogen and possible environmental concerns.

Water Deficits

Although severe drought rarely occurs in the Atlantic region, periods of prolonged dry weather have caused yield reductions in a variety of crops. Climatic data can help determine how often water deficits occur. There is considerable variability in water deficits

within the Atlantic Region as a result of both climatic and soil variability.

The crop water balance depends on the kind of crop, the stage of development, soil characteristics, and the climate. Most crops will have higher yields when they have a steady adequate supply of water. In some instances it is necessary to irrigate to maintain an optimum soil water content. Information on daily rainfall and evaporation, combined with crop and soil characteristics are the basic components of any weather-based irrigation scheduling system. The purpose of such systems is to estimate the soil water content so that the appropriate quantity of water can be applied at the right time to maintain optimum crop growth.

A loam soil will hold about 16 mm of water per 0.1 m of soil depth. The total water content in 0.5 m of loam top soil is about 80 mm however, only about 50% of the total water available can be removed before crop growth is slowed and only about 65 mm of soil water is actually available to the crop. Sandy soil of the same depth may hold in total 45 mm out of which only 40 mm is actually available to the crop. During mid-summer, crop water use can vary from 4 to 8 mm per day. Using a figure of 6 mm per day, in a week the 40 mm of soil water in this example would be gone and crop growth would suffer.

Mulches and plastic reduce water loss from the soil early in the season and can improve germination. Once the crop is well established and the rows are covered by foliage, water loss from the soil surface is only a small part of that used by the crop. Some discussion on the water requirements of specific crop groups can be found in the section "Soil and Water Management".

Microclimate Modification

The climate of the farm level can be modified from the general climate of the region in order to improve production. The two major climatic factors affecting crop growth are temperature and water. After identifying the specific requirements of each crop it is then possible to evaluate what methods are available to optimize conditions for growth. The advantages of enhanced productivity and the higher prices of the early season market must be compared to higher costs of production.

Temperature

In Atlantic Canada the two most important concerns regarding temperature for vegetable production are to increase minimum temperatures to prevent frost damage and to increase maximum temperatures in order to promote faster growth.

Several methods are available to prevent frost damage to crops. Some are expensive; however, when compared to the market value of the crop and its possible loss, they are a good investment. Similarly, the cost of production associated with promoting faster growth by increasing the amount of heat the crop receives must be evaluated in light of higher early season prices and greater flexibility in crop and hybrid selection that can reach maturity.

Frost Modification

Frost free periods in Atlantic Canada vary tremendously due primarily to topography and proximity to large water bodies. The distribution of spring and fall frost dates are mapped in the publication "The climate for Agriculture in Atlantic Canada" Agdex No. 070, and presented in tabular form for selected locations in the publication "The Probability of Freezing Temperatures in Atlantic Canada," Agcan. Pub# 1565. Site selection is a passive form of increasing the frost free period on a farm while irrigation and plastic are two active methods.

Site Selection: Where available land permits, the best means of avoiding late spring and early fall frosts is through proper selection of the field. Cold air runs downhill and will accumulate in hollows or depressions. It is, therefore, very important to avoid valley bottoms or areas where cold air can be trapped. On sloped land a border of trees on the downslope side of a field can trap cold air coming from further up the slope. In instances such as this, a pathway must be cleared in the trees to permit cold air to flow away from the production site to lower land. If possible, a midslope site is the best for avoiding frosts. A hilltop site is better than a valley bottom but will be less desirable than a midslope site, except in coastal areas.

Where possible, land that is immediately adjacent to a large water body will benefit from the heat holding capacity of the water, resulting in a longer frost free season.

Irrigation: Irrigation is successfully used to prevent frost damage to crops. The continual freezing of liquid water results in heat being given off to the plant. Protection as low as $-7°$ C can be attained, depending upon wind conditions. High winds cause evaporative cooling and also interfere with the distribution of the water. Most radiative frosts are not associated with high winds, however. When using irrigation, a system must be selected that will provide a continuous film of liquid water. If a sufficient amount of liquid water is not present, damage will occur that is often worse than having no irrigation protection at all.

The ability of the soil to handle larger volumes of water particularly in the spring, must be considered in Atlantic Canada.

Plastic: Clear single layered polyethylene does not provide much frost protection at the best of times and under certain atmospheric conditions, can actually be worse than no cover at all. New plastics are being developed that provide better protection; however, more than 3° C protection is unlikely at present.

Heavy accumulations of condensation will improve protection slightly, provided the condensation remains on the film.

The maximum frost protection found in studies in Atlantic Canada revealed 1-2° C protection for clear polyethylene row tunnels under ideal conditions. Double walled tunnels provided 2-4° C protection. Large structures that house sensitive crops should rely on supplemental heating systems to protect from frost.

Heat Modification

The promotion of rapid growth is primarily a result of warm temperatures. Two to three weeks earlier production can often be attained by providing additional heat for many crops and also new crops can be grown, which in our climate would not normally reach maturity.

A comparison of normal or average Growing Degree Days above 5° C and above 10° C are mapped for the Atlantic Region in the publication, "The Climate for Agriculture in Atlantic Canada", Agdex No. 070. A detailed account of growing degree days is given in "Growing Degree Days and Crop Production in Canada", Ag. Canada Publication No. 1635.

Heat units can be modified by any means that will regulate the temperature the crop experiences. For most practical purposes there are two methods to increase daytime heating, windbreaks and plastic.

Windbreaks: The amount of heat a plant receives is a complicated process. Solar energy heats the plant directly, and heat from the surrounding air and soil indirectly. If air movement takes place around the crop, this transfer of heat from the adjacent air and soil will be diminished. Any method of reducing the air movement near the crop will result in more heat being available for the plant.

Windbreaks can benefit the crop environment by providing more heat, better humidity and less mechanical damage. Careful attention must be paid to disease and insects when using windbreaks.

The effectiveness of a windbreak to the leeward side is measured in the number of heights of the windbreak. Therefore, if a windbreak is 5 m tall it will cover a greater horizontal distance than if it were only 2 m tall. However, the density or porosity of a windbreak is also important. The denser the windbreak, the greater the reduction in wind at a distance very close to the break ie. 1-3 heights from the windbreak, however at a distance of 8-10 heights the wind reduction is very small. When a windbreak is less dense the wind reduction very close to the break is moderately reduced but the wind reduction extends to a much greater distance from the break. Generally, 50% porosity will provide an effective reduction in wind at 10-15 heights to the leeward side. Of course, the windbreak should be oriented perpendicular to the direction of the prevailing winds at the time of year protection is required. During our growing season in Atlantic Canada this is usually from the south and southwest, however local landforms can modify this.

Plastic: All plastic enclosures and mulches provide an increase in heat unit accumulation compared to outside air temperatures.

Clear polyethylene row covers can provide an increase in daytime maximum temperatures of 10-20° C depending upon the amount of direct sunshine. This results in accelerated growth. Precautions should be taken to avoid excessive daytime heating by providing a method of ventilating the enclosure on warm days. Ventilation can be achieved through installing holes and slits in the poly, however this method should not be used when frost risk is high as holes will lessen even more the protection the plastic may afford. Manual lifting of the row tunnels is often used to prevent overheating. Temperatures in excess of 50° C have been measured and clear plastic enclosures could prove lethal to the crop if not ventilated during hot days. It is best to maintain the optimum temperature range for the crop under the plastic. Plastic is most advantageous on cool early season days when inside temperatures are favorable for plant growth compared to outside air temperatures. Later in the heat of summer, plastic may not be advantageous.

Plastic should be removed from a crop when the plants come in contact with the cover.

Similar advantages in growth are found in larger structures as well. Ventilation is still required on hot days.

Black plastic mulches can provide modest increases in soil temperature of 1-3° C for depths of 5-20 cm providing strong solar radiation is present and there is good soil contact. At night, however, black plastic slows the convection of soil heat to between the plastic and the soil surface, the crop then can be more susceptible to frosts. Surface temperatures on the black plastic of 65° C have been measured. It is, therefore, important that transplants do not touch the plastic surface and the transplants are well watered at planting.

Clear plastic mulch provides better soil heating than black plastic; however, there is a problem with weed control.

Floating plastic mulches provide moderate increases in daytime heating and require less daytime ventilation than row tunnels. In addition, floating mulches do no present a physical barrier to the crop growth as the cover actually will permit expansion in size of the crop.

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IV Soil and Water Management

Vegetables can be grown on diverse soils, but good yields and quality depend on adequate fertility, uninterrupted drainage and on satisfaction of the crop's water and other physical demands. Selection of suitable fields as well as improvement and maintenance of favourable soil physical condition is the initial, basic element needed to ensure successful vegetable production.

Soil Physical Properties

Soil moisture regime, texture, structure and organic matter content are soil physical properties that affect, in interaction with other crop production factors, yield, quality and maturity of vegetable crops. Management of soils for vegetable production must utilize soils whose physical properties do not severely limit production. This is of major concern because the majority of soils in this region suffer in at least one serious physical limitation: excessive moisture (impeded drainage), poor structure (compactness), unfavourable (extreme) texture, stoniness or excessive slope.

Drainage

Impeded drainage, characterized by excessive moisture content within the root zone, for a significant period during the growing season, is one of the most common causes of poor production. The reason for the condition may be clay-like soil texture, poor structure, compacted subsoil, topography or poor soil management. Impeded drainage causes poor aeration and unfavourable soil temperature (cooler) regime, causing poor root development, low efficiency of fertilizer use and accumulation of plant-toxic compounds in the topsoil. Also soil trafficability and use of machinery is reduced and the chance of pest and disease damage is greatly increased.

Soil Structure

Compacted subsoils, commonly found as close to the soil surface as 20 cm, can be thin (5 to 30 cm) single layers that are formed naturally, or caused by improperly applied soil management. These "pans" may be continuous or patchy and are underlaid by less dense and more permeable soil. Man-induced "pans" are caused by repeated, excessive and untimely tillage, use of tillage equipment that damages soil structure, depletion of soil of organic matter and untimely traffic over the field. Many compacted subsoils are very dense, continued in deep layers that are naturally formed (lodgment, basal till).

Soil Texture

The texture of a mineral soil is determined by the proportions of sand, silt and clay as well as coarse fractions (gravel and stones). Loam contains sand, silt and clay in the approximate ratio of 2:2:1. Loamy soils, sometimes called "medium" textured, have favourable physical characteristics such as good drainage, water retention, favourable structure and are easy to till. Soils with a much higher sand fraction may be subject to poor water retention and leaching, while clay and silty soils are often poorly drained and sensitive to structure damage: "slumping", crusting (capping) and cracking. Tillage is often difficult, and tillage while soil is wet often results in formation of clods.

Organic Matter

Most mineral soils contain between 1 and 5 percent of organic matter. Topsoil used for vegetable production should contain in excess of 3 percent organic matter. The organic matter, besides being a minor source of plant nutrient and an important agent in moisture retention, has an important role to play in maintaining soil structure. This is done by binding soil particles together into stable crumbs and aggregates. This, in turn, facilitates water penetration and drainage and allows roots to grow without hindrance.

Poor soil structure may be the result of extreme texture such as prevalence of clay, silt or sand, or poor soil management. Structure and soil physical properties in general can be improved by drainage improvements and by increasing the soil organic matter content.

Liming

The main purpose of liming is to correct soil acidity but soil structure also benefits from liming. Both calcium and to a lesser extent, magnesium, help to stabilize soil aggregates and so improves structure. By promoting crop growth and microbiological activity, lime contributes to root proliferation and humus production from the breakdown of organic matter. See the APASCC Publication 534-84, "Atlantic Soils Need Lime".

Drainage

Effectively managing the periodic excess of water that occurs in Atlantic Canada is just as important as supplying adequate water during periods of drought at critical stages of crop growth.

Poor drainage is detrimental to vegetable production. When the field with impeded drainage is considered for vegetable production, obtain advice from the Department of Agriculture Specialists with respect to the most suitable drainage improvement method, suitable crop selection and soil management techniques. There are a number of techniques designed to improve moisture regime, each of them best suited to particular conditions. The moisture regime improvement methods include subsurface tiling, ditching, land forming, subsoiling and raised bed forming. The last

two methods listed not only improve the moisture regime itself, but also increase effective soil depth available for root penetration.

Organic Matter and Crop Rotation

Addition of organic matter may take the form of farm-yard manure, compost or peat and green manuring, where a crop is grown simply for ploughing down (eg winter rye or buckwheat).

Soil organic matter breaks down rapidly under the intense cultivation associated with vegetable production. While rotations including grass sod crops are most effective in maintaining organic matter, it may be necessary to rely on green-manure and cover crops where such rotations are not feasible. Ideally, grass should appear in the rotation twice every four to five years but at the very least once every three years. Sod crops are important in the rotation since they maintain porosity and good structure in fine-textured soils. (clay & silts) They also improve the water-holding capacity of sandy and gravelly soils. In addition to maintaining good soil structure, the organic matter helps to control several common soil-borne vegetable diseases.

These benefits are greatest on soil which is adequately fertilized. The best fall seeded crops appear to be fall rye or Italian rye grass, with rye grass being an effective crop for spring planting.

Soil Acidity and Liming

Acid soil contains minerals and complex compounds that are toxic to crops. Also efficiency of fertilizer use is sharply decreased with increased acidity. It is of utmost importance to understand acidity and amend the soil by liming.

The pH scale ranging from 0-14 is used to indicate acidity or alkalinity. A pH value of 7.0 indicates neutral; values below 7.0 indicate acid and those above 7.0, alkaline. One should realize that a difference of one unit of pH is in effect a ten fold difference in actual soil acidity or alkalinity. Most vegetable crops grow well in a mineral soil with a pH range of 6.0 to 6.5 and in an organic (peat) soil with a pH range of 5.5 to 6.0.

To correct soil acidity, ground limestone or other liming materials are broadcast and worked into the soil. The rates and type (calcitic, dolomitic) of liming material should be determined by a soil test. As it takes many months for lime to neutralize the soil, fall liming is preferred to a spring application. Do not overlime! Micronutrient deficiencies are most likely to appear on fields that have been limed to values over 6.8.

Seedbed Preparation

This aspect of vegetable culture is probably the most important and one of the most difficult to achieve. A poor seedbed will affect germination, seedling establishment and, ultimately, yield and quality.

A germinating seed requires warmth, air and water. As mentioned previously, a well drained soil of good structure will be warmer than its poorer counterparts. The crumbs will retain water while, at the same time, allowing drainage of excess water to keep air spaces open. Furthermore, good structure will guard against "slumping" and compaction as well as reduce the probability of crusting (all these factors present serious physical barriers to germinating seeds).

Seedlings also must be protected as much as possible from weeds, diseases and pests which compete with or threaten the young plant. Many specific pesticide programmes have been developed and should, of course, be employed before and after seeding. Intensive vegetable production often employs a system of general soil sterilization especially for seedbeds. This ensures a general "kill" of disease inoculum, insects, nematodes and weeds (including their seeds).

Final soil preparation before sowing may include harrowing rolling and dragging until the soil surface is smooth and clod-free. Formation of raised beds is becoming common practice; this facilitates drainage from the seedling root zone and lessens the risk of compaction from wheel tracks.

Do not overtill the soil. Use tillage equipment sparingly especially those which damage soil structure such as roto-tillers, disks, packs and drags. Do not till when the soil is extremely wet or dry.

Fertilizer Materials

All fertilizer salts are toxic to germinating seeds and to plant roots, if applied in sufficient concentration near the seed. Fertilizers vary in toxicity per unit of plant nutrient due to : (1) differences in the amount of salts contained in the fertilizer per unit of plant nutrient; (2) differences in solubility of the salts in the soil; and (3) a few specific materials or elements are particularly toxic to plant roots (for example, boron). Phosphate fertilizers usually do not injure plant roots. The concentration of phosphorus in the soil solution at any one time is very low.

1. Nitrogen Sources

Nitrogen Materials	Form	% Nitrogen (N)
Anhydrous Ammonia	Gaseous	82
Ammonium nitrate*	Dry	33 to 34
Urea*	Dry	45 to 46
Ammonium sulfate	Dry	20
Ammonium nitrate-urea (UAN)	Liquid	28
Ammonium nitrate-urea (UAN)	Liquid	32
Calcium ammonium nitrate*	Dry	17
Calcium nitrate	Dry	15.5

*Nitrogen materials in common use in bulk-blended fertilizers in Atlantic Canada.

Nitrogen fertilizers are available in dry, liquid and gaseous forms. Which of these forms to use is a matter of choice for the individual vegetable grower, depending upon availability of the material, equipment for handling, cost per kilogram of nitrogen, the cost of application and grower preference.

Ammonium nitrate and ammonium sulfate are similar in toxicity to plants and much safer than urea. Urea is toxic when banded with or near the seed but is not toxic to plant roots when broadcast at rates normally used. Fertilizers containing more than half as much nitrogen as phosphate frequently contain urea.

2. Phosphate Sources

Phosphate Materials	% Phosphate (P_2O_5)
Superphosphate	18 to 20
Triple super phosphate*	44 to 46
Monoammonium phosphate (MAP) [11% N]	50 to 54
Diammonium phosphate (DAP) [18% N]*	46

*Phosphorus materials in common use in bulk-blended fertilizers in Atlantic Canada.

Most common phosphate fertilizers are not very toxic to seeds and plants and no limit is normally set for the safe rate which may be applied near the seed of vegetable crops.

Diammonium phosphate (DAP) is more toxic than other phosphate fertilizers; thus, more care should be taken than is required with MAP (particularly with sensitive seeds and coarse soils).

3. Potash Sources

Potash Materials	% Potash (K_2O)
Muriate of potash*	60
Sulfate of potash*	50
Sulfate of potash-magnesia [11% Mg]	22
Potassium nitrate [13% N]	44

*Potash materials in common use in bulk-blended fertilizers in Atlantic Canada.

Muriate of potash (KCl) is the most common source of potassium in fertilizers, and is less toxic per unit of plant nutrients than most nitrogen fertilizers; sulfate of potash (K_2SO_4) is even less toxic while sulfate of potash-magnesia has approximately the same toxicity per unit of potassium as muriate of potash.

Potassium nitrate is one of the safer sources of potassium when considered as a nitrogen source.

Fertilizers containing micronutrients (boron, copper, iron, manganese or zinc) are more toxic than the same grades without micronutrients, and maximum safe rates should be reduced. Boron is particularly toxic.

Fertilizer Placement

Phosphorus is most important for early growth and is more available if placed near the seed. For transplant crops, the use of high-phosphorus starter solution may be beneficial.

Nitrogen fertilizers readily dissolve in the soil water and move easily through the soil to the plant roots. Placement of nitrogen is less important than for phosphorus. Part of the nitrogen requirements is usually broadcast, injected or worked into the soil before planting, often to hasten the breakdown of a cover crop. Much of the nitrogen is not applied until side-dressing, in order to conserve the fertilizer from leaching, or to restrain plants from too much vegetative growth.

Too much potassium applied in a band at planting or in the transplant water can injure young seedlings and reduce crop yield and quality. This danger of fertilizer injury is greater on sands and sandy loams than on silt loam and clay loam soils. On the coarse-textured sands and sandy loams part of the potassium fertilizer requirements should be broadcast and worked into the soil before planting.

Starter Solutions

Water soluble fertilizers (e.g. 10-52-10) and liquid fertilizers (e.g. 6-24-6) which contain N, P, and K are used as starter solutions at planting time to stimulate the growth of young transplants.

Side-dressing

The purpose of side-dressing is to supply additional nutrients during growth of the crop. Most commonly, nitrogen is the nutrient that is supplied after the plant has reached a certain stage of development. With crops that produce fruit (e.g. peppers or tomatoes) it is important not to have too much vegetative growth early in the season, or flowers will not develop, or may drop off if they do develop. For this reason, it is usually advisable to put only a moderate amount of nitrogen in the soil at the time of seeding or planting. After the plant has set some fruit and is no longer in danger of becoming excessively vegetative, extra nitrogen can be applied. The timing and amount of nitrogen side-dressing must be judged from the appearance of the plants. On coarse, sandy soil it may be advisable to add potash as well as nitrogen.

Fertilizer Through The Irrigation System

Many fertilizers, but particularly nitrogen, may be applied through the irrigation system during the growing season. In some crops it is difficult to move along the rows with machinery without damaging the plants, whereas the irrigation water will penetrate evenly over the whole area without damaging the plants.

General Fertilizer Requirements

The requirement of a crop for any one of the fertilizer elements depends on many factors specific to the particular field and intended use of the crop. For example, the actual requirement for nitrogen can be affected by the previous crop, plant population, weather, cultivars selected, and whether the crop is to be marketed directly from the field or stored. The requirement for all fertilizer elements varies between direct seeding or transplanted production as well as date of establishment. In general the closer an element can be applied to the actual time of use by the particular crop and after as much of the variability created by the climate (such as excessive rainfall) is known the more effectively the requirements can be determined. The following tables provide a general guideline to the requirements for nitrogen, phosphorus, potassium, and micronutrients for various vegetable crops under differing production management systems.

Table 1: Nitrogen Requirements of Vegetable Crops on Mineral Soils (Kg/Ha of N)

Crop	Soil Production Management System			
	A	B	C	D
Asparagus	100	140	90	60
Beans (dry or snap)	40	70	30	20
Beets	60	90	50	30
Carrots	100	140	90	60
Celery	150	200	140	110
Cole Crops	150	200	140	110
Cucumbers	80	120	70	50
Lettuce	150	200	140	110
Onions	120	160	110	80
Parsnips	100	140	90	60
Peas	40	70	30	20
Peppers	80	120	70	50
Pumpkins	80	120	70	50
Radish	60	90	50	30
Rhubarb	150	200	140	110
Rutabagas	40	70	30	20
Spinach	100	140	90	60
Squash	80	120	70	50
Sweet Corn	120	160	110	80
Tomatoes	100	140	90	60
Turnips	40	70	30	20

*A – Row crop rotation (no plowdown)
B – Heavily cropped soils (low in organic matter)
C – Crop to follow a mixed sod plowdown
D – Crop to follow a legume sod plowdown

Table 2: Phosphorus and Potassium Requirements of Vegetable Crops on Mineral Soil (Kg/Ha of P_2O_5 and Kg/Ha of K_2O)

Crop	Phosphorus				Potassium			
	Low	Medium	High	Very High	Low	Medium	High	Very High
Asparagus	200	150	100	50	350	250	150	100
Beans (dry or snap)	60	45	30	0	75	50	25	0
Beets	200	150	100	50	175	125	75	25
Carrots	200	150	100	50	175	125	75	25
Celery	250	200	150	75	350	250	150	100
Cole Crops	250	200	150	75	175	125	75	25
Cucumbers	250	200	150	75	75	50	25	0
Lettuce	250	200	150	75	250	175	100	75
Onions	250	200	150	75	175	125	75	25
Parsnips	200	150	100	50	175	125	75	25
Peas	60	45	30	0	75	50	25	0
Peppers	200	150	100	50	175	125	75	25
Pumpkins	200	150	100	50	175	125	75	25
Radish	100	60	40	20	75	50	25	0
Rhubarb	200	150	100	50	250	175	100	75
Rutabagas	200	150	100	50	175	125	75	25
Spinach	100	60	40	20	250	175	100	75
Squash	200	150	100	50	175	125	75	25
Sweet Corn	200	150	100	50	250	175	100	75
Tomatoes	250	200	150	75	250	175	100	75
Tomatoes*	100	60	40	20	175	125	75	25
Turnips	200	150	100	50	175	125	75	25

*Maximum rates for banding of fertilizer at transplanting.

1) These are general requirements for broadcast applications and may be reduced for band applications. Specific recommendations for each crop require a Soil Test.

2) Results from field experiments indicate that less fertilizer is required under mulch, especially on high fertility soils. This is due to the reduced leaching under mulch. Over fertilization favors vegetative growth and thus may delay maturity and even reduce yields.

Table 3: Micronutrient Sources and Typical Rates of Applications

Nutrient	Common Sources	Application Rate of Actual Element Soil Kg/ha	Foliar Kg/1000 L
Calcium (Ca)	Calcium chloride 36% Ca	–	2.2 - 4.0
	Calcium nitrate 20% Ca	–	1.2 - 3.4
Magnesium (Mg)	Dolomitic limestone 6 - 13% Mg	27.5 - 33.0	–
	Epsom Salts (magnesium sulfate) 9.6% Mg	27.5 - 33.0	3 - 5
	Sulfate of potash-magnesium 11% Mg	17.0 - 22.5	–
Boron (B)	Various sources are available 8 - 21% B	1.0 - 3.0	0.2 - 0.6
Copper (Cu)	Copper sulfate 13 - 25% Cu	7.0 - 14.5	0.5 - 1.5
	Copper chelates 9 - 13% Cu	–	–
	Copper oxide 60 - 80% Cu	–	–
Manganese (Mn)	Manganese sulfate 26 - 28% Mn	–	0.5 - 1.0
	Manganese chelates 9 - 12% Mn	–	–
Molybdenum (Mo)	Sodium molybdate 39% Mo	–	0.1 - 0.25
Zinc (Zn)	Zinc sulfate 36% Zn	4.0 - 12.0	0.6
	Zinc chelates 9 - 14% Zn	1.0 - 2.0	–
	Zinc oxide 78 - 80% Zn	4.0 - 12.0	–

Water Requirements

Water constitutes 80 - 95 percent of the fresh weight of vegetable crops. The availability of water is desirable at all stages of growth for all crops; however, there are, for each crop, additional critical periods. All vegetables share one or more of the following uses for water:

1. As an aid in germination of seeds
2. In establishing transplants
3. To convey fertilizer to the root zone.

Adequate moisture must be available to germinate the crop, whether direct-seeded or subsequently transplanted. For direct-seeded crops, this involves difficult decisions for the farmer, especially where irrigation is not available. The best policy is to prepare the field for sowing and to sow after rain has brought the soil moisture to a level approaching field capacity. Soils with significant proportions of clay or organic matter will retain moisture, (therefore staying at optimal condition for seeding) for longer periods. Rain or irrigation after sowing may cause a physical barrier to emerging seedlings such as carrots. Anti-crustant materials have been tested for their effectiveness in preventing this barrier from forming; sawdust appears to be the most effective and can be applied as a thin layer in a narrow band over the seed row.

Transplanting leads to a traumatic shock for all plants. Considerable damage may be done to the roots and water loss may exceed uptake until new roots grow; thus, wilting occurs. Seedlings produced in cells (such as in the "Speedling" system) will, of course, receive considerably less setback. "Hardening-off", by reducing the level of watering prior to transplanting, may give plants a better ability to withstand shock.

Water is an important medium to carry fertilizer to the roots after top-dressing on dry soil. It can also be beneficial when soil is already at a high moisture level, especially where nitrogen may have been leached after heavy rains.

Water Requirements for Specific Crops:

A. Leafy vegetables

The cole crops, lettuce, celery and spinach need a fairly constant and abundant supply of moisture for maximum yields. The soil should thus ideally be adequately moist in the root zone at all times. The highest yields and best quality usually result when there have been no checks to growth because of a shortage of water or nutrients. It should be emphasized that, especially with the leafy vegetables, maximum response to water depends also on a sufficient supply of nutrients, particularly nitrogen.

Celery benefits greatly from an even supply of water; soils with high moisture-holding properties such as peat bogs are therefore well-suited to celery production. Cauliflower, when subject to early water stress, may later exhibit harmful effects such as premature heading or "buttoning".

Transplanted crops need water most critically at two periods of growth: until they are established and in the last two weeks before harvest. This latter period is when rapid growth (and, therefore, yield increase) occurs. If irrigation is feasible to supplement rainfall, it can profitably be employed. Water in excess of 25 mm during this rapid growth period should be avoided in cabbage and lettuce, to avoid the danger of burst heads. Brussels sprouts have the greatest need for water during the first period (establishment); it is unlikely that water needs at harvest maturation warrant irrigation except in extremely dry years.

B. "Fruit" vegetables

The legumes (peas and beans) respond best to adequate water during flowering and pod development. After germination, an over-supply of water should be avoided since it may lead to excessive stem and leaf growth, as well as disease. Watering during pod development will tend to increase seeds per pod, size of individual seeds and delay the onset of toughness.

Other "fruit" vegetables (tomatoes, squash, cucumbers, peppers and sweet corn) also require water, especially at the time of flowering and fruit development. Outdoor tomatoes will not normally need

water between establishment of the transplants and the onset of flowering. (Those grown in bags of peat or compost will probably need regular water because of root restriction). Water shortage during fruiting will result in smaller fruits and lower yields as well as aggravating physiological problems such as blossom-end rot. On the other hand, maximum yields may be accompanied by a poorer flavour compared with fruit grown under drier conditions. The optimum water requirement will depend, in such cases, on grower experience and judgment.

Sweet corn, after establishment, does not normally suffer from dry conditions until flowering (tasseling). Water, at this point, whether as fortuitous rain or well-timed irrigation, will ensure a full set of well-filled kernels.

Cucurbits (cucumbers, squash) benefit from plentiful, though not excessive, water throughout their life. Rapid growth to build up leaf area is essential at first; after fruit-set, water is required to swell the fleshy fruits.

C. Root vegetables

Carrots, parsnips, turnips, rutabagas and radish do not respond favourably to a high amount of water; lush top growth will result at the expense of root development. Ideally, soil should remain relatively (but not excessively) dry. Sudden increases in soil moisture after a dry spell may cause cracking, especially in carrots and parsnips.

D. Onions

Onions benefit from adequate soil moisture while developing a deep root system. After this, response to water is not so marked. Wet conditions during the later stages of bulb formation may delay maturity and affect adversely the storage life of the bulbs.

Irrigation

The actual water requirement of vegetable crops depends on many factors such as soil type, depth of soil and plant root characteristics.

However for continuous vigorous growth of vegetable crops, they require a uniform supply of approximately 25 mm of rainfall per week. Whenever rainfall amounts are less than this, supplemental irrigation water should be considered. Irrigation is thus as important a consideration as cultivar, fertilizer or pest control in producing optimum yields.

Water available for crop growth depends upon the soil's ability to retain water following rainfall or irrigation. Sands and coarse sandy loams retain less than 25 mm of water in the top 30 cm of soil, or a supply for no more than 7 day's crop growth. On these soils a weekly schedule of 25 mm of water from rainfall or irrigation maintains high crop yields. Heavier applications of irrigation water waste fertilizer by leaching nutrients from the root zone. Excessive irrigation may cause crop injury by moving herbicides from the soil surface to crop roots.

Fine sandy loams and silty loams retain 40 to 60 mm of water for crop growth. On these soils heavier and less frequent irrigations improve crop yield. Irrigations can be scheduled every 10 to 14 days at rates to provide a total of 40 to 50 mm of rainfall or irrigation.

Irrigation to cool crops during hot weather may increase crop yield. Cooling results when field heat evaporates irrigation water from crop and soil. Irrigation-cooling has only recently become practical, with solid-set system and automatic controls and valves which continually turn on and off series of sprinklers in a field. The water required for irrigation-cooling is less than the amount needed for soil irrigation. Rates of 2 mm of water per hour for 2 to 3 hours are effective. Irrigation-cooling is scheduled when air temperature is 30° C or higher at noon.

References

See the general reference section.

The Fertilizer Handbook. 1976. Published by The Fertilizer Institute, Washington D.C. 20036.

V Vegetable Transplant Production and Management

Plants of high quality and vigor may be produced in a greenhouse for season long crop plantings. This allows the producer to set healthy growing plants to the field for early production, better weed control and/or more effective use of the land.

Vigorous, healthy transplants grow and mature quickly, enabling the producer to market a quality crop earlier, often at higher market prices. Poor transplants may not respond, even to the best conditions in the field. Each crop varies in its response to transplant shock and environmental conditions during field growth.

Plant Growing Structures

Polyethylene Greenhouses

The most economical and easily constructed growing structures are polyethylene greenhouses. Adequate attention should be given to heating and ventilation systems which can either be manually or automatically operated. Only crops requiring similar growing conditions should be grown in the same greenhouse.

Detailed information on greenhouse construction and operation can be obtained from each of the provincial Departments of Agriculture.

Hot Beds and Cold Frames

Growers for many years have used structures known as hot beds and cold frames. These are of similar construction to greenhouses. Hot beds are heated with manure, hot air, hot water, steam or electricity, while the cold frames are unheated.

Cold frames are used mainly to harden plants grown in the heated structures, but the labor required is greater, and the temperature is more difficult to control, than in equipped plastic greenhouses.

Plans for cold frames are available from each of the provincial Departments of Agriculture.

Seeds

Only top quality seed of recommended cultivars from a reputable seed company should be used. Seeds treated to control diseases and insects are recommended.

Some companies provide precision sized seeds of a high germination percentage and seedling vigor, for use in module trays or peat blocks. Sometimes these seeds can be coated for use with automatic seeders.

Growing Media

A growing media has three major portions - air, solids and water. The air space is needed to provide oxygen for wet respiration, to allow nutrification, and some microbial activity. The air space in a mix complements the water portion, since air replaces the water absorbed by the plant roots. The air/water ratio in a mix is determined by the particle size of the solids. A coarse mix has relatively more air and less water-filled pore space than a fine mix.

After watering, several of the soilless mixes will have 75% of the total space filled by water with the remainder taken up by solids and air. In a soil mix, solids compose 50% of the space with the balance divided between air and water. This basic difference between a soil and soilless mix therefore necessitates different crop management.

Preparing A Growing Media

There are several considerations:

1. Water-holding capacity
2. air porosity
3. nutrient availability
4. buffering capacity
5. weight
6. price.

A mix should perform four basic functions for plants:

1. Provide an anchor system for the plant roots.
2. Store water for plant-root absorption.
3. Provide nutrients in the water solution that can be absorbed by the roots.
4. Provide oxygen (air spaces) for root respiration.

Taken from Soilless Mixes, OMAF Agdex 296/510

Commercial Prepared Mixes

Commercially prepared soilless mixes are available with the pH adjusted, trace elements added and usually contain a small amount of fertilizer. A ready made mix is often the most economical especially when comparing the cost of labor to preparing a mix. There is a wide selection of prepared mixes available with different peat ratios and fertilizer formulations. The prepared mixes are generally consistant but a soil sample should be taken so the grower knows the initial pH and total salts.

Preparing A Soil Or Soilless Mix

Soil mixes are generally a 1-2-1 formulation with 25-30% soil, 50% peat moss and 25-30% an aggregate such as vermiculite, perlite or sand. Soilless mixes are 50-100% peat moss with perlite, vermiculite, polystyrene chips or sand being added for aeration.

Soil

A field soil to be used in a growing media should be friable, uniform, well-aerated yet capable of holding moisture with a pH of 6.0 - 6.5. The field should be free of potentially toxic chemicals such as herbicides and high total soluble salts.

Soil Pasteurization

Soil used in a growing media should be pasteurized. Soil is pasteurized to reduce harmful soil diseases such as damping off and clubroot, bacteria, weed seeds and nematodes. Most harmful organisms can be eliminated in the soil by maintaining a temperature of 60° C for 20 minutes throughout the root zone. This can be accomplished with steam or an electric soil pasteurizer. Chemical fumigants can be used to eliminate soil-borne insects, diseases, nematodes and weeds.

Peat Moss

Peat moss is the remains of dead plant material that builds up in layers in a peat bog. Sphagnum peat moss is the most desirable for a growing medium. Peat moss has a high cation exchange capacity which makes peat moss suitable for a nutrient reserve and a buffering agent. Peat moss in the natural state contains very few nutrients and has a low pH (3.5 - 4.5), and is considered free of active pathogenic diseases.

Coarse Aggregate

Vermiculite

Vermiculite is a micro mineral which has been expanded by heating at 900° C. It has a platelike structure which enables it to retain both water and fertilizer. The pH of vermiculite is near neutral and it contains significant quantities of available potassium and magnesium.

Perlite

Perlite is a silicaceous volcanic rock which when crushed and heated to about 1000° C expands like popcorn. It has a low cation exchange capacity and a pH of 7.0. It is inert and primarily added to the mix to improve aeration.

Sand

Sand is often added to a mix to provide weight. A sharp sand should be used as the rounded sand often plugs up drainage space reducing air space.

Polystryene Chips

Polystryene chips are a by-product of polystryene bead boards. The material is near pH 7.0 and has a low cation exchange capacity and is inert. It is added to provide aeration.

Soil Mix

Top soil or compost	.25 cubic metre
sphagnum peat moss	.50 cubic metre
aggregate: vermiculite, perlite or sand	.25 cubic metre
superphosphate (0-20-0)	3 kg
ground limestone	5 kg
	1.0 cubic meter

Soilless Mix

sphagnum peat moss	.50 cubic metre
aggregate: vermiculite, perlite or sand	.50 cubic metre
limestone	3 to 5 kg
superphosphate (0-20-0)	1 to 5 kg
trace elements (FTE 302)	75 g
or trace elements (FTE 555)	110 g
calcium or potassium nitrate	500 g
magnesium sulfate ($MgSO_4$)	300 g
wetting agent	100 mL
Borax (11%)	20 mL
Iron Chelate 138	35 mL
	1.0 cubic meter

Fertility

Use one of the following programs:

1. Complete soluble fertilizers may be added while watering the plants. The approximate rate is 9 g per square meter, or as directed, and this may be repeated as required or approximately every 10 days. Formulations containing trace elements are prepared especially for greenhouse growing and are available as soluble 15-30-15, 20-20-20. Use a fertilizer low in ammonia nitrogen such as the formulations designed for soilless mixes such as 15-15-18 or peat-lite special.
2. These soluble fertilizers mixed dry will supply adequate nutrition for 5 weeks:
   Soluble 15-30-15 or 20-20-20 — 1.5 kg per cubic meter
3. This fertilizer combination mixed dry will supply adequate nutrition for up to 5 weeks:
   Potassium nitrate (14-0-44) — 0.5 kg per cubic meter
   Superphosphate (20%) — 0.1 kg per cubic meter
4. This fertilizer combination mixed dry will supply adequate nutrition for up to 5 weeks.
   Nutricote and Nitritrace — use label rate

Cautions

1. Reduce rates for seedling flats by 1/3 to 1/2.

2. Commercial field fertilizer mixtures such as *6-12-12 should not be used unless the* amount of ingredients in the mix are known. High analysis mixtures (15-30-15, 12-24-24) should be avoided because of high ammonium release.

3. To avoid possible trace elements or minor element deficiency, include when mixing:
   FTE (fritted trace element) 50 mL per cubic meter

4. Wetting Agents: a nonionic surfactant such as Aquagrow may be used to speed wetting — 100 mL per cubic meter. Agrol 90 may also be used.

Speciality Crop Germination Benches

In order to maintain germination temperatures, a thermostatically controlled heated bench is recommended. Flats can be covered with white plastic to conserve moisture and speed germination. Flats should be inspected twice a day at the time of germination. Remove cover as soon as plants are through the soil.

Growing Conditions

Proper conditions of temperature, moisture and light are necessary for the production of quality transplants.
(a) Light — Care should be taken to locate and construct the greenhouse so that plants receive the maximum amount of sunlight.
(b) Temperature — A slightly higher temperature is required during daylight periods than at night or in periods of low light. Newly planted seed flats require a higher temperature and constant moisture to promote germination. When temperatures are maintained at too high a level after germination the plants become "leggy", "soft" and susceptible to diseases. Low temperatures result in stunted plants. Growing temperatures below 10° C for lengthy periods may cause bolting (formation of seed stalks) in cole crops and celery.
(c) Moisture — Plants require adequate water for normal growth. Overwatering causes succulent plants that are more susceptible to damping-off. Underwatering results in slow, stunted growth.

Transplant Growing Schedule

Crop	Time In Greenhouse (Weeks)	Germination Temp (C)	Growing Temp (C)	Space In Flats Cubic cm.	Plants/ Square Meter	Plants/ Grams Of Seed	Seed For 1 ha.
Cauliflower	6 - 7	21	16	16 - 32	300 - 600	200	300 g
Cabbage	5 - 7	21	10 - 16	16 - 32	300 - 600	200	300 g
Celery	10 - 12	21 - 24	16 - 18	13 - 25	400 - 750	500	150 g
Lettuce	6 - 8	21	10 - 16	13 - 25	400 - 750	350	250 g
Cucumber	2 - 4	24	18 - 24	100	100	20	3 Kg
Onion	10	16 - 18	16	3	3000	150	1 Kg
Pepper	9 - 10	21 - 24	16 - 18	25 -40	250 - 400	50	550 g
Tomato	5 - 8	21	16 - 18	40 - 50	200 - 250	150	300 g
Squash	2 - 4	24	18 - 20	100	100	7	5 Kg

Hardening Crop

Transplants should not be over-hardened because of the danger of permanent stunting. Cabbage, cauliflower and onions may be hardened by reducing the temperature to between 10 and 12° C, or in the case of lettuce, to 9 - 10° C, while at the same time reducing watering. Squash, cucumbers and melons should be hardened only by reducing moisture. In the 2 weeks prior to transplanting it is advisable not to supplement nitrogen in the medium. Reduction of N, as with moisture, serves to prepare the plant for transplanting by toughening it up. A boost of N can be supplied at, or just immediately prior to transplanting.

Containers for Plant Growing

Many growers are using flats with individual cells (modules) to produce transplants. This type of flat has the following advantages:
1. ease of handling
2. little or no transplanting shock
3. mechanization of seeding and field transplanting

The use of modules require proper watering as the small amount of soil mix in each cell leads to faster drying of the soil. These plants are also more prone to nutrient deficiencies. Therefore, more frequent watering and feeding is required. The initial capital cost of equipment and seeding trays along with maintenance costs do add to plant production costs. There are two main types: a rectangular cell and an inverted pyramid, shaped cell, such as a speedling tray.

Soil blocks, peat pellets and Jiffy 7's are also in use. For further information consult your Vegetable Specialist since technology is progressing rapidly in this area of transplant systems.

Greenhouse Cleanup

After vegetables transplants have been removed from the greenhouse (and empty), it should be disinfected to prevent organisms from carrying over. Spray the inside structure with either:

1) Sodium hypochlorite 5-6% - 1 part to 9 parts water

2) Formaldehyde - 1 part to 40 parts water

The greenhouse should be closed for 3-4 days and then ventilated. These solutions can also be used to disinfect benches, flats, water spouts, seedling trays, etc. Always wear suitable respirators and protective clothing when applying the above chemicals.

Seeds

Approximate Number Per Gram

Crop	Seeds Per Gram
Asparagus	50
Bean, snap	2-3
Beet, Swiss Chard	50
Broccoli	320
Brussels Sprouts	280
Cabbage	300
Chinese Cabbage	250
Cauliflower	350
Celery, Celeriac	1,800
Chicory	600
Corn	4-8
Cucumber	40
Eggplant	200
Endive	550
Kale	270
Kohlrabi	280
Leek	350
Lettuce	700
Melon	40
Onion	280
Parsley	550
Parsnip	200
Pepper	150
Pumpkin	4
Radish	125
Rutabaga	280
Spinach	90
Squash	10
Tomato	350
Watermelon	10

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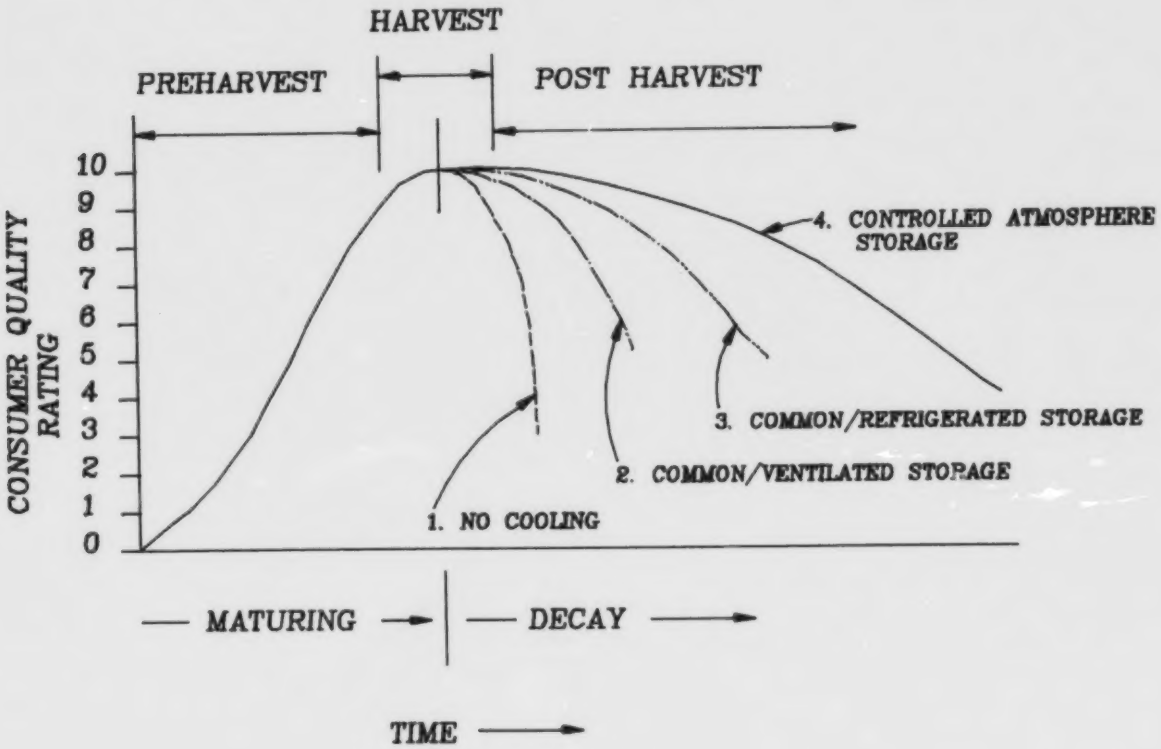
VI Post Harvest Handling

Introduction

Physiology, Respiration, and Moisture Loss:

Fruit and vegetables are living, breathing organisms and continue to do so even after harvest. An understanding of this process is important for proper post-harvest handling of produce.

Harvesting of produce is carried out at the stage of growth which will preserve the optimum maturity, and quality, until the time of consumption. The maturing of produce continues to a point, of optimum crispness, firmness, flavour and other desired qualities. After this point, the growth process continues and 'consumer qualities' begin to decline. Produce may become tough, spongy, limp, or have other undesirable characteristics. The objective in harvest and post harvest treatments of produce is to maintain the optimum 'consumer quality' until the projected time of consumption. Figure 1 depicts this maturing process under various conditions versus time.



Post harvest maturation is influenced by the produce respiration process. This can be summarized in equation form as follows:

Sugar + O_2 = CO_2 + H_2O + Heat of Respiration
(oxygen) (carbon dioxide) (water)

High respiration accelerates product deterioration consumes sugars and other energy reserves and releases respiration heat. Respiration is highest in vegetables picked at an immature stage. To preserve the 'consumer quality' respiration must be reduced to a slower rate by cooling the product as soon as possible. An analogy is that of the fuel consumption of an engine running at idle contrasted with the fuel consumption while running at high speed and under full load. A vegetable contains the fuel (sugar) for the respiration process. The consumption of fuel is comparable to the loss in product quality. By reducing the product temperature, this maturing process can be reduced to an idle. The object in harvest and post-harvest treatment of produce is to pick the crop just before appropriate maturity and control the rate at

which further maturing takes place.

Also of prime importance in the post harvest handling of produce is moisture loss. Even with the storage temperatures maintained at acceptable levels, the produce can give up its moisture by means other than respiration. This will occur because the air in the storage may act as a 'sponge', and absorb moisture if it is less than saturated (i.e. less than 100% relative humidity). Produce will release moisture in this way if the air has less than the recommended relative humidity. Table 1 depicts accepted values for produce storage temperatures and air relative humidities. The effects of the refrigeration equipment on produce moisture loss will be discussed further in the Section "Equipment and Materials".

Table 1:

Recommended storage temperatures, relative humidities, storage life expectancies and the highest freezing points of fresh vegetables

Vegetable	Temperature ° C	Relative humidity	Approximate length of storage period	Highest freezing point
Asparagus	0.0	95	3 weeks	− 0.6
Beans green or snap	7.2-10.0	85-90	8-10 days	− 0.7
Beets, bunched	0.0	90-95	10-14 days	− 0.4(tops)
topped	0.0	90-95	1-3 months	− 0.9
Broccoli (Italian or sprouting)	0.0	90-95	1 week	− 0.6
Brussels sprouts	0.0	90-95	1 week	− 0.8
Cabbage, early	0.0	90-95	3-4 weeks	− 0.9
late	0.0	90-95	3-4 months	− 0.2
Carrots, bunched	0.0-1.1	95	2 weeks	
topped	0.0-1.1	95	4-5 months	− 1.4
Cauliflower	0.0	90-95	2 weeks	− 0.8
Celery	0.0	95 +	3 months	− 0.2
Corn, sweet	0.0	90-95	8 days	− 0.6
Cucumbers	7.2-10.0	95	10-14 days	− 0.5
Kohlrabi	0.0	90-95	2-4 weeks	− 1.0
Leeks, green	0.0	90-95	1-3 months	− 0.7
Lettuce, head	0.0	95	2-3 weeks	− 0.2
Onion sets	0.0	70-75	5-7 months	
Onions, green	0.0	95-100	2 weeks	
Onions, dry	0.0	50-70	5-9 months	− 0.3
Parsnips	0.0	95	2-4 months	− 0.3
Peas, green	0.0	95	1-2 weeks	− 1.2
Peppers, sweet	7.2-10.0	70-75	2-3 months	− 0.7
Pumpkins	7.0-10.0	70-75	2-3 months	− 0.8
Radish spring, bunched	0.0	95-100	2 weeks	− 0.4
winter	0.0	95-100	2-4 months	− 0.7
Rhubarb	0.0	95-100	2-3 weeks	− 0.3
Rutabagas or Turnip	0.0	95-100	6 months	− 1.1
Spinach	0.0	95-100	10-14 days	− 0.3
Squash, summer	7.0-10.0	70-75	2 weeks	− 0.5
winter	7.0-10.0	70-75	6 weeks	− 0.7
zucchini	5.0	95	1-2 weeks	− 0.5
Tomatoes, ripe	10.0	85-90	3-5 days	− 0.5
mature green	13.0	85-90	2-6 weeks	− 0.8

* After Agriculture Canada Publication 1532 (1974) Commercial Storage of Fruits and Vegetables.

Pre-storage Conditioning

Pre-Cooling:

Cooling the product as soon as possible following harvest is critical to ensure the consumer is provided with a product of premium quality. The effects of prolonged, rapid respiration have been discussed. Table 2 shows the respiration rates of selected produce at various temperatures prior to, during and after cooling.

Table 2 Heat of Respiration and Specific Heat of Fresh Fruits and Vegetables when Stored at Various Temperatures[1]

Commodity	Heat of Respiration, Btu per ton per day at indicated temperature[2]				Specific Heat
	32° F	40° -41° F	59° -60° F	68° -70° F	77° -80° F	Btu/lb ° F
Asparagus	6,200-13,200	13,000-23,100	25,500-51,500	38,300- 59,200	81,800-104,700	.94
Beans, snap	5,500- 9,000	9,200-11,400	32,100-44,100	45,400- 53,000	—	.91
Beets, topped	2,700	4,100	7,200	—	—	.90
Broccoli, sprouting	4,100- 4,700	7,600-35,200	38,200-74,800	61,200- 75,000	123,200-193,600	.92
Brussels sprouts	2,200- 6,600	4,800-10,600	14,100-29,900	18,900- 37,800	—	.88
Cabbage	1,000- 1,400	1,700- 2,700	4,100- 5,700	6,100- 10,800	10,700- 14,000	.94
Carrots	2,100- 4,500	2,800- 5,800	5,700-11,800	10,100- 20,900	—	.91
Cauliflower, trimmed	3,600- 4,200	4,200- 4,800	9,400-10,800	16,500- 18,900	18,500- 30,800	.93
Celery	1,600	2,400	8,200	14,200	—	.95
Corn, sweet, with husks	6,600-11,300	9,400-18,300	33,300-38,400	59,000- 68,400	62,000- 95,800	.79
Cucumbers	—	—	3,300- 7,300	3,100- 10,600	4,200-12,100	.97
Leeks	2,100- 3,700	4,300- 6,400	18,200-25,700	—	23,600- 26,100	.88
Lettuce, head	1,300- 3,700	2,900- 4,400	7,000- 9,900	11,200- 13,200	16,100- 20,100	.96
Melons:						
Cantaloupes	1,100- 1,300	1,900- 2,200	7,400- 8,500	9,800- 14,200	13,700- 15,700	.94
Parsnips	2,600- 3,400	1,900- 3,900	7,100- 9,400	—	—	.83
Peas, green, shelled	10,400-16,600	17,400-21,400	—	76,700-122,400	—	.79
Peppers, sweet	—	1,100- 4,700	4,400-12,600	5,000- 14,300	7,900- 16,300	.94
Potatoes, immature	—	2,600	2,900- 6,800	4,000- 9,900	—	.85
Potatoes, mature	—	600- 1,900	1,300- 2,600	1,800- 3,500	—	.82
Spinach	4,200- 4,900	7,600-12,700	29,500-49,200	37,900- 63,200	—	.94

[1] Summarized from USDA Handbook 66.

[2] Values may be reduced as much as 50% during CA storage.

The heat to be removed in cooling the product is referred to as field heat. It can be represented in equation form as follows:

Q	=	W	×	C	×	T
(Field Heat)		(Product Weight)		(Specific Heat)		(Temperature Change)

The precooling capacity is the rate at which this heat can be removed and is expressed in either British Thermal Units per Hour (btu/hr) or kilowatts (kW). The actual cooling capacity is arrived at through a balance between the desired rate of cooling to preserve product quality, and the type, size and cost of the equipment to achieve those results.

Several methods are available for removing the field heat and reducing the respiration rate.

Air-Cooling:

The most common method of reducing product temperature is by air cooling. This is accomplished by forcing cold air around and past the produce. The rate of cooling is dependent upon the following:

(1) Air Temperature;

(2) Air flow rate past the produce and;

(3) The rate at which heat can move through and out of the product to the air.

The third factor can differ for each product type and variety.

A number of factors are considered in designing an air pre-cooling system. The product's response to the air flow rate and temperature must be known or determined. This can be accomplished by placing produce in crates or bins in the air flow, and in temperature conditions as it will actually be in the post-harvest system. It's temperature variation versus time is then measured. Published values from previous work are available and are normally expressed as one-half or seven-eights cooling time (this is the time taken to cool the produce 1/2 or 7/8 of the difference between the initial product temperature and the temperature of the cooling medium). These figures are then used to determine the cooling capacity required for the anticipated harvest rate, and subsequently size the refrigeration equipment. A typical air flow requirement for cooling is 5 cubic meters of air per minute per kilogram of product. (Note: in air precooling systems the heat given off by the respiration of the crop during cooling can be significant and therefore should be included in any heat balance calculations.)

Hydro-cooling:

Hydro cooling systems take advantage of the increased heat transfer rate between the product and refrigerated water. Cooling times much faster than those obtained with air systems are possible. The equipment is sized by similar methods as air precooling but, due to the faster cooling times needed, larger capacity equipment is indicated. Hydrocooling

is done most effectively by submerging the produce in water, however, by spraying large volumes of water over it, acceptable cooling results can also be attained.

Vacuum Cooling:

The fastest cooling method for vegetables with a high surface area to volume ratio (i.e. lettuce), is vacuum cooling. Its main advantage is in pre-cooling produce which tends to have slow cooling rates with air or water methods. Cooling is accomplished by 'forcing' water to boil at low pressure (i.e. vacuum) and thus extracting heat from the product. Cooling is achieved in several minutes. Caution must be taken to ensure that over cooling of the crop does not result. Since cooling is accomplished by evaporating moisture, over-cooling will result in freezing and/or dehydration of the product. Pre-cooling is usually limited to 1/2 to 3/4 cool (1/2 to 3/4 of the difference between initial and desired temperature) and the remainder of the heat extracted by other methods. The other advantage of vacuum cooling is that product can be packaged in cartons prior to cooling. This can result in less handling of the crop and therefore faster processing from field to storage.

Flaked Ice or Slush Ice Cooling:

Flaked and slush ice is normally used for reducing product temperature from the precooled temperature to the final desired storage temperature. The product releases heat much slower as the product temperature approaches that of the cooling medium, as is the situation in the later stages of precooling. Also if the product is to be packaged immediately following precooling, this final 'ice' cooling can be done in the carton as the product is being shipped or stored. This 'iced' cooling alleviates the difficulties caused by the insulating characteristics of the packages and cartons.

In calculating the ice requirements for this final cooling, the latent heat of fusion (heat required to convert ice to water) is used. 335 KJ of heat is required to melt one kg of ice at 0.0° C. The total amount of ice required is determined from the heat to be removed from the product, the heat of respiration and the heat gained from the surroundings.

Storage Methods

The objective of a product storage is to continue to preserve the 'consumer quality' until the time of consumption. Respiration and moisture loss must continue to be restricted during this period.

Storages are designed to control three conditions: first is temperature; second is relative humidity and third is gas concentrations of the air. The latter is presently being used only for selected crops in specialized storages. All storages involve restricting the supply of inputs to the respiration process (i.e. heat, oxygen) and effecting saturation of the "demand" for a product of respiration (i.e. carbon dioxide). The types of storage in use at present are summarized in the order in which they have developed.

Common Storage:

In the absence of refrigeration equipment, a common storage relies on precooling by cool ambient conditions at harvest (i.e. produce is cool before entering). Temperature control during storage is by ventilation with cool outside air and may be possible only during the night in early fall. During the winter period, ventilation to maintain desired temperature must be done with caution to avoid freezing and excessive product moisture loss by the cold, dry air. For this reason, this type of storage is acceptable only for selected produce. Product which is relatively resistant to moisture loss and has a relatively low respiration rate can be stored for specific periods. In order to maintain 'consumer quality' to February and later, very strict control must be maintained on the temperature in the storage and mechanical humidification is advisable. Often a high storage loss is accepted in this system rather than pursue the alternative which is a more sophisticated, and expensive storage system. However, as the demand for high quality produce by the consumer increases, the amount of product lost due to storage may warrant the expense of an alternate type of system.

Common Refrigerated:

In this type of storage, refrigeration equipment controls the temperature, and increased insulation and sealing reduces heat gain and air infiltration. Refrigeration equipment properly specified and supplied will provide a close tolerance on temperature control (typically ± 1° C). The main disadvantage in this system is the continuing moisture removal from the air — and therefore product — by the evaporator coils. This is evident by the ice buildup and/or condensate run off from the coils. The evaporator coils are designed to provide their rated cooling capacity at a specific t.d. value. The minimum t.d. value is normally 3 to 4° C. This value is a relationship between the coil temperature and the inlet and exhaust air temperature across the coils. The dehumidifying effect of an evaporator coil is inherent in its design. If the resulting condensation of moisture from the air causes an excessively low relative humidity, then humidification must also be designed into the storage.

Only certain types of produce are suited to extended term refrigerated common storages. The continued moisture loss by the product is normally the determing factor in achieving the maximum length of storage.

Jacketed:

In any storage, the objective is to minimize the difference between the temperature of the refrigerating medium and the air in order to minimize the dehumidification of the air. As pointed out previously, a t.d. of 3 to 4° C is normally minimum for a conventional refrigerating coil system.

A jacketed storage system accomplishes a lower t.d. value by increasing the surface area of the cooling medium to effect the cooling process by small temperature differences. Construction of the building is

similar to other storages but with an air recirculation chamber around the inside walls and ceiling of the room. The product is "sealed" inside the room by a polyethylene jacket. The air recirculated around the outside of the jacket (in the "chamber") is cooled by a conventional refrigeration system and is maintained at a low relative humidity. Inside the room, the air is at high relative humidity and the desired temperature. It is critical in this system that no air leakage occurs between the room and refrigeration air, or outside air.

The main advantage of this system is the high relative humidities which can be maintained in the storage room. Also by reducing the relative humidity of the recirculated air, the refrigeration system will operate at a higher efficiency due to a higher t.d. and reduced freezing on the coils.

Disadvantages include slow heat removal rates across the polyethylene jacket making it inappropriate for precooling requirements; somewhat more expensive in regard to construction costs than common refrigerated storage; more complicated with two separate air recirculation systems — one inside the storage room and one around the jacket chamber, and the difficulty in avoiding air leakage across the jacket over prolonged periods of time.

Controlled Atmosphere:

A controlled atmosphere (C.A.) storage is constructed similarly to a common refrigerated storage except that extreme care must be taken in insulating, interior cladding and sealing, to ensure absolute air tightness. In order to test for air tightness, the room can be pressurized and held at a raised air pressure for a period of several hours.

Prior to placing in the storage, the produce must be precooled to the desired temperature. Following this, the room is sealed and the oxygen level is reduced (by scrubbing or burning) and the carbon dioxide levels are increased to predetermined levels. A refrigeration system is used to maintain the desired temperature in the store as in common refrigerated storages. Since the respiration process is effectively minimized, and the relative humidities are maintained at a reasonably high level, the produce can be held for extended periods of time with only minimal loss in product quality.

At present only selected produce such as cabbage can be held under controlled atmosphere conditions. Further research is necessary to broaden the scope of produce which can be held in this manner.

A C.A. storage may be relatively expensive to construct and maintain since a perfect air seal is necessary. In addition, a refrigeration system is required although the capacity requirements during storage may not be as high as for conventional storages.

Equipment and Materials

Insulation:

The main purpose of insulation is to reduce the transfer of heat to and from the storage room. In addition to its heat transfer qualities it should also be selected with the following criteria as well:

(1) resistant to the transfer and absorption of moisture.

(2) aid in the sealing of the storage room from air and gas leakage.

(3) be of long life (not prone to deterioration or decay).

(4) protect the structural components of the building from decay.

There are several types of rigid insulations available which meet these specifications. The most common are the extruded 'polymer type' insulations.

Interior Cladding:

Many types of materials have been tried as interior cladding in storages and many have met with little success in withstanding the elements. High humidities have accelerated the failure rate of most materials.

Wood products — even those designed for exterior service — have not had an acceptable life span. Rigid polyethylene sheets 3/16" — 1.4" thick and precoated metal cladding appear to provide the essential qualities. When selecting cladding material, specify the following criteria:

(1) moisture proof — against absorption and transmittance.

(2) sealable at all corners and edges (moisture, air and gas).

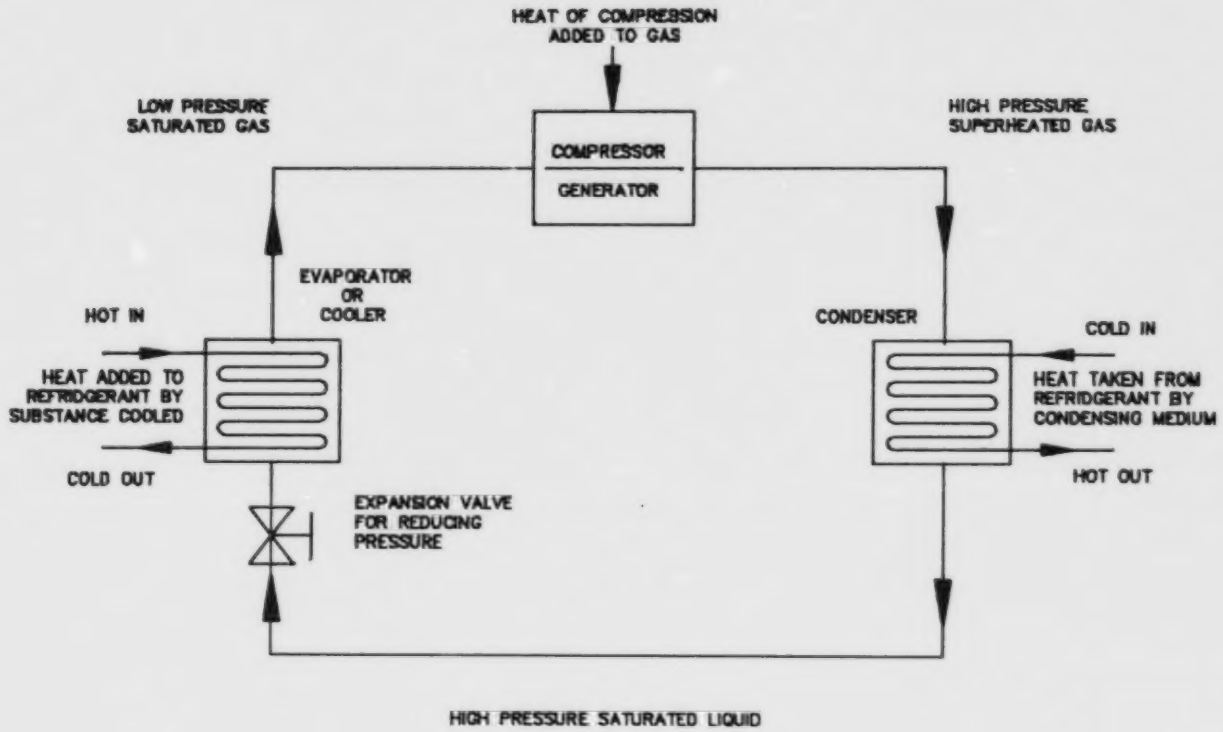
(3) impermeable and not conducive to microbial growth and decay.

(4) can be readily cleaned and disinfected.

Although the initial cost of the cladding meeting these criteria may appear high, experience with wood and other products has shown their short life span makes them even more expensive.

Refrigeration Equipment:

A refrigeration system involves a closed cycle process in which heat is absorbed as a liquid, is evaporated to a gas, and the heat dissipated as it is compressed to a liquid. This is for the purpose of transferring heat from a low temperature source and exhausting it at a higher temperature. In this case the low temperature source is the produce, through the evaporator, and the high temperature exhaust is through the condenser/compressor. See Fig. 2



In removing heat from produce the following processes occur within the system:

(1) A cooling medium (air or water) is recirculated around the product.

(2) Heat moves from the product to the air or water.

(3) The cooling medium is recirculated past the refrigeration coils.

(4) Heat is removed from the cooling medium and transferred to the refrigerant — as with conventional evaporator coils. With a ice-bank® system, the initial cooling medium is the air which is recirculated through both the product and the cooling tower; a secondary cooling medium of water is used to collect the heat from the air and move it to the ice tank where the freeze/thaw cycle of water transfers this heat to the evaporating refrigerant in the "ice plates" (or pipes).

(5) The heat is removed from the refrigerant by the compressor and condensor.

The main components of the refrigeration system are the evaporator coils, the compressor, the condenser and the necessary valves and controls to effect the cycle.

In a conventional refrigeration system, the evaporator coils have the most obvious effect on stored produce. The temperature maintained on the coils is controlled by the rate of the refrigerant evaporation process. The t.d. value, as previously described, directly relates this temperature to the design storage temperature. Also, all the heat from the storage must be absorbed by the evaporation process. Therefore, in specifying the evaporator coils they must have a low t.d. value (3 to 4° C) (or higher if the RH can be lower) and have a cooling capacity, equal to the heat to be removed from the storage. In conjunction with this are the fans which recirculate the storage air past the coils. Again this fan capacity is directly matched to the heat load. It is a common misconception that these fans are to remove the heat from the produce and transfer it to the coils. This is not so! A secondary air recirculation system is necessary to assist in the transfer of heat from the product to the air. The evaporator-coil fans only assist in moving the air past the coils at the pre-determined rate and thus only to transfer the heat to the coils.

In an ice-bank® system however, the air recirculation fan is designed to move air past the product and the secondary cooling medium which is the recirculated water. The designed rate is in the range of 2 to 8 cubic meters per hour per kilogram of product to be cooled. The rate of water recirculation in this system is designed to maintain an air temperature of 1 to 2° C at the design capacity. The compressor and condenser equipment is equivalent for both the conventional and ice-bank® system.

In selecting and specifying equipment types for a storage the following information is necessary in order for the equipment supplier to properly size the equipment:

(1) Maximum and normal product harvest rates — specify each type of product separately — express in both kg./hr. and kg./day and include total load.

(2) Maximum and normal product temperature at harvest.

(3) Desired storage temperature.

(4) Maximum time allowable for cooling.

(5) Desired storage Relative Humidity.

With this information the supplier can propose a size and type of equipment which will meet your requirements. The proposal from the supplier should include the specific performance figures for his equipment, such as capacity in KW, t.d., evaporator temperature, discharge temperature and compressor horsepower.

Should you wish assistance in interpreting the information provided with the refrigeration equipment or other components of the storage, your extension agricultural engineer can be of assistance.

Grading and Packing

Refer to the Canada Agricultural Products Standards Act, Fresh Fruit and Vegetable Regulations for grade requirements.

An integrated grading and packing system can take many forms depending on the crop to be packed, the volume of product and the intended market. It will incorporate one or more of the following features: a method of grading and culling the product; washing, disinfection, and disease control; waxing, film wrapping or labelling of product units and, finally, packing of units in boxes or crates, which may include package ice.

There are many suppliers of packing and grading equipment. Choose machinery and layouts which suit the particular situation and which are flexible enough to accommodate anticipated future changes. It is imperative that the final production line is free from "bottle necks" to allow free passage of product from field to storage or shipping container.

In many cases, packing precedes pre-cooling; containers then must be designed to facilitate the chosen pre-cooling method (water proofed, ventilated, etc.) Grading, packing, and pre-cooling must occupy the minimum length of time possible and subsequent re-warming before ultimate storage or shipping should be avoided.

Sanitation and Disease Control

Every effort should be made to minimize the effect of rot and mold organisms in storage rooms. In addition to attacking stored produce, they can cause deterioration of wooden containers and structual materials, and cause objectionable odors that may taint stored produce. In advance of loading, a storeroom should be thoroughly cleaned. The storage bins, walls and floors should be washed thoroughly with hot soapy water using a high pressure spray and rinse, ensuring that all mud and crop residue is removed. This is followed by a spray of live steam or disinfectant (consult Publication 1400A for disinfectant recommendations). The choice of disinfectant will depend on price, and type of surface being treated. Some disinfectants are corrosive on metal or plastic. More porous materials such as brick and wood require more thorough cleaning than concrete, metal or plastic surfaces. The surface should be kept wet with disinfectant for at least 10 minutes, preferably 30 minutes. Be sure to protect all electrical equipment while washing or disinfecting. When rooms are not in use growth of molds can be reduced by keeping the room warm and ventilated. Regular washing and disinfection of machinery, and harvest and grading tools, is also recommended.

Immature or over-mature produce should not be considered for long term storage. Careful handling to eliminate bruising or rupturing of the skin is imperative to reduce deterioration during storage. In order to reduce pathogen growth on stored produce, condensation of water should be avoided by adjusting temperature, humidity and air circulation.

In mixed storage rooms that include fruits, vegetables, eggs and/or dairy products, activated carbon air filters may be used to prevent odor contamination.

Storage Compatability

It may be necessary to use the same store room or storage facility for several vegetables or fruits. Certain crops cannot be stored in the same store room because they will reduce the quality of other products. This is particularly important in long term storage. Some fruits (ie. apples, pears, tomatoes) produce a volatile gas, ethylene, which can initiate sprouting of potatoes, carrots and onions; cause senscence of leafy vegetables; and induce bitterness in carrots. Vegetables should not be stored in rooms with these fruits or in rooms that have just been used for long term storage of these fruits.

Onions can transfer their flavor to other vegetables and root crops such as potato may impart an earthy flavor to fruits. Other vegetables are incompatible because they require different temperatures or humidities. Table 3 can be used as a guide if it is necessary to store several commodities together.

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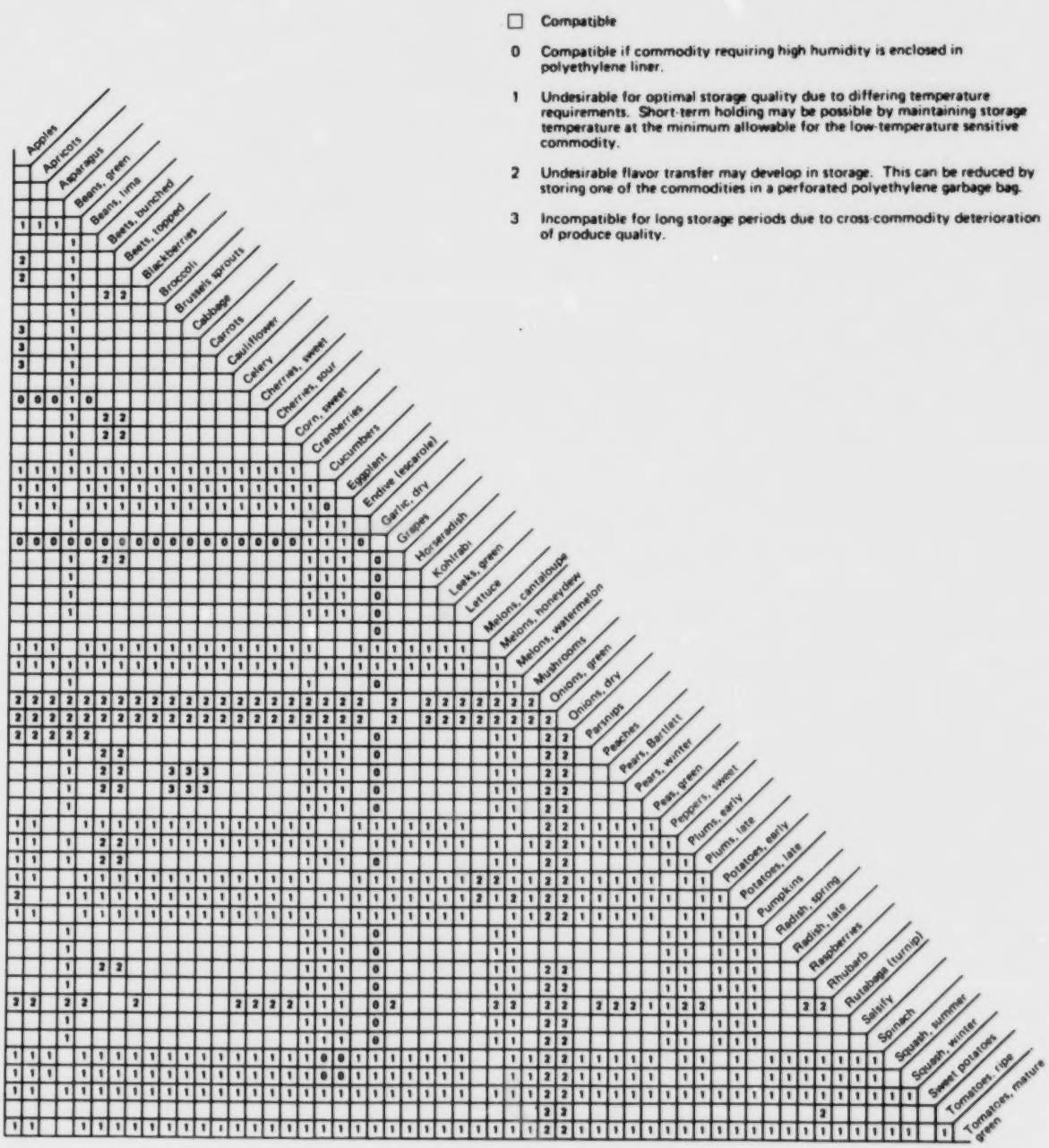
Table 3 Storage Compatibility of Fresh Fruits and Vegetables*

*After Agriculture Canada Publication 1478E (1978) Home Storage Room for Fruits and Vegetables.



VII Mechanizing Vegetable Production

Tillage

Tillage is the process of preparing a suitable soil environment for seed germination and plant growth. A tillage operation must be evaluated on the basis of its ability to adequately perform one or more of the following goals:

1) Management of crop residue
2) Soil aeration
3) Weed control
4) Incorporation of fertilizers and manures
5) Insect control
6) Temperature control for germination
7) Improvement of soil condition
8) Provide good seed to soil contact
9) Prepare surface for further operations

However, contrary to common belief, soil can be over-worked resulting in damage to soil structure and wasted effort. If a tillage practice does not increase yield, it should be eliminated or changed.

Primary Tillage

First of all, what is primary tillage? Primary tillage is the cultivation or working of soil to depths greater than 10 cm. The usual figure given is 15-25 cm. The two main implements used to accomplish this in growing market vegetables are the moldboard plow and the PTO powered rotary tiller.

Moldboard Plows

Good plowing is fundamental to the success of following cultivations and of the crop itself. Secondary cultivation can initially hide poor plowing but sooner or later, the truth will show. Poor plowing could result in uneven plow depth which will affect root penetration and cause inconsistent crop growth and maturity.

Since trash burial is the one thing a moldboard plow can do better than any other implement, it is important to fully utilize this advantage. If trash is not fully buried, it will not rot properly. This, along with the extra work and energy required to repair a poorly plowed field, is the reason care must be taken in primary tillage.

The objectives of plowing are:

1) to bury crop residue
2) to aerate the soil
3) to control weeds, insects and crop disease
4) to incorporate lime and fertilizer into the soil

A good plowing job should sandwich organic matter between the furrow slices to form wicks which will accelerate water absorption and decomposition of residue.

Good plowing also increases soil porosity and aeration which will also increase decomposition and release nutrients to the soil. A furrow should retain a distinct crown. This helps reduce runoff. It also reduces ponding and increases moisture infiltration resulting in speedier surface drying.

Choosing the right plow for your particular operation requires more thought than purchasing the biggest unit your tractor can handle. Plows are of four various types. Mounted, semi-mounted, trailing and reversible. Due to plow size and hp requirements we will not discuss the semi-mounted or trailing plow to any extent. The plow most commonly used in vegetable growing is the mounted or integral plow. The advantage of this unit is its maneuverability and relative cost per bottom. Also, it makes the most efficient use of tractor draft. However, it requires more operator skill and plow adjustment to perform a proper plowing job.

In order to adjust a plow, you must understand the underlying principle. The working part of any moldboard plow is the bottom. The main plow bottom parts are the moldboard, share, shin and landside which are all attached to a common structure called a frog.

The plow bottom has a wedging action through the soil which exerts pressure upward and sideways to the open furrow resulting in a turning effect. As a result of this action, soil will shear, causing granulation and/or crumbling. As plow speed is increased, so is soil pulverization.

It is important that plow bottoms run level. If bottoms are out of level, a non-uniform pressure is exerted on the turning soil resulting in poor plow performance, poor granulation, and a remarkable increase in horsepower and plow wear.

The plow coulters will also greatly effect the performance of a moldboard plow. The three most common types of coulters are the smooth or plain coulter, notched coulter and the rippled edge coulter. The plain coulter is recommended where ground penetration may cause problems. Also, these coulters are easily resharpened. The notched and ripple edge coulters are commonly used for plowing under heavy trash.

If a coulter is improperly adjusted, it could result in any of the following conditions:

- abnormal plow wear
- ridges and valleys in the plowed field
- rough riding during secondary tillage
- excessive passes during secondary tillage

A rough rule of thumb for coulter adjustment under average conditions is to set the coulter 5 to 10 cm ahead of the share point.

If plowing is on extremely hard ground where penetration may be difficult, the coulter should be raised and moved towards the share point. However, under extremely trashy conditions, you may have to move the coulter forward to provide more clearance. Also,

if the coulter is set too deep, it may push the trash rather than cut it.

As discussed earlier, the plow bottom must run level. If the bottom runs level, so should the plow frame run level with the land. The main factor to consider in most mounted plows is tractor-hitch linkage which should be adjusted according to the tractor plow operator's manual. To level the plow from front to back, the tractor's top linkage will require adjustments. To check for a level running plow, measure the depth of the furrow behind the front and rear bottoms. Also sight along the frame of the plow to make sure it runs level with the lay of the land.

Before the width of cut adjustments are made, the plow must level in field conditions.

Mounted plows generally lack means for significant lateral adjustments, therefore wheel width adjustment is important. The plow manuals will show proper tread setting which is normally expressed in cm from center of tractor to the inside of the rear tire.

Width of cut of the front bottom of integral plows is adjustable by rotating the offset hitch bar. Rotating the bar clockwise will turn the plow towards the land increasing the width of cut. A counter clockwise rotation will lead the plow towards the furrow. Always recheck coulter adjustment after alterning width of cut. Improper adjustments will cause excessive plow wear and side draft.

Rotary Tillers are sometimes used in vegetable production. Among the reasons for their use are:

- minimal seedbed preparation
- reduced draft
- reduction in soil compaction

In many cases, rotary tillers will provide a negative draft. That is, they will assist the tractor in its forward motion. Care must be taken in operating tillage equipment in wet conditions, especially rotary tillers. This could result in serious damage to the soil by causing the formation of large clods and soil smearing.

To estimate power requirements for a rotary tiller, the following formula could be used:

$$\text{Drawbar hp} = \frac{\text{Draft (inch lbs.)} \times \text{speed (mph)}}{375}$$

For example, in medium soil a rotary tiller 54" wide would have a draft equivalent of 30 psi. Therefore, rotary tilling 5" deep would give a draft of

$$5" \times 30 \text{ psi} \times \text{width } 54" = 8100$$

$$\text{hp} = \frac{8100 \times 2 \text{ mph}}{375} = 43 \text{ hp}$$

PTO hp = approximately 125% of drawbar power

$43 \times 1.25 = 54$ hp

Thus, it is apparent that heavy soil, faster forward speed and depth of tillage greatly affect hp requirements.

Other advantages of the rotary tiller are that they do a good job of chopping and mixing trash with the soil. However, the moldboard plow still does a better job of completely covering the trash. Many rotary tillers are equipped with removable and/or adjustable blades enabling them to work as a cultivator. Some units can be equipped with a toolbar to enable the attachment of an auxiliary unit such as a seeder or fertilizer spreader.

Operation of a Rotary Tiller. Rotary tillers must be properly adjusted and operated if they are to do a good job.

The degree of soil pulverization is mostly affected by the size of the bite and the angle of the soil shield. Other factors such as soil type, moisture and amount of crop residue present are also important.

The size of the cut or bite is determined by tractor speed, rotor speed and number of blades. By increasing tractor forward speed, the tiller blades will increase the size of bite. However, this will also require more horsepower. Rotor speed can be changed on most tillers by a gear box or reinstalling or alternating easily accessible gears. With proper matching of rotor and forward speeds, a good tilth can be obtained. As operating depth increases, size of bite decreases, therefore requiring alteration to forward and/or rotor speed.

Warning — adequate horsepower is needed to maintain forward travel speed. If there is insufficient hp, one tends to overpulverize the soil. Average speed is between 3 and 8 km/h.

Hood or shield adjustments are important in the performance of a rotary tiller. When the shield is lowered, soil from the blades is thrown out against it, resulting in the clods being broken up. If the shield is raised, large clods leave the rotor without being broken up. This would be recommended for any fall work which is to be reworked in the spring.

The rotary tiller blades are arranged in a spiral pattern so that no more than one blade strikes the soil at any one time. In wet sticky soil, it may be desirable to remove several blades and speed up the rotor but care should be taken that the spiral pattern is not altered. All soil cut by the blades enters the rotor and is discharged out the back. If the soil remains in the rotor, it is obvious that it will soon plug. Plugging is affected by rotor diameter, speed, blade arrangement, soil moisture and trash.

There are only a few field adjustments on a rotor tiller and these are necessary for satisfactory performance. Some of these we have discussed and others are self explanatory.

1) Adjusting work depth with gauge shoes

2) Alter rotor speed

3) Alter forward speed

4) Raise or lower rear shield

5) Change the number of blades or their arrangements on the rotor.

Level the unit from side to side with tractor linkage bar and front to back by the top linkage.

Secondary Tillage

The primary objective of secondary tillage is to prepare a seedbed. Although there are a great number of different machines used for seedbed preparation, the objectives all lead toward breaking soil crust, shattering clods, and smoothing and firming the soil. This will result in closing air pockets, killing weeds and helping aerate the soil.

A good seedbed requires that soil closely surround the seed for maximum water absorption. It is important to have quick germination and rapid development of a root system.

Disc harrows have several advantages in preparing a seed bed. They generally do a better job of fertilizer incorporation. Discs are least affected by rocks and stumps because of the rolling action. Discs will tend to pulverize lumps, close air spaces, mulch the surface and provide a firm, smooth, uniform seedbed.

Discs can be divided into two classes: the mounted disc and the trailing disc. Since the mounted discs are much more maneuverable in smaller fields, we will limit our discussion to these units. A mounted disc is usually limited in size to the lifting capability of the tractor hydraulics and tractor front end stability. The depth of soil penetration is usually controlled by disc angle and tractor hydraulics.

A mounted disc can be divided into three categories:

1) single action
2) double action tandem
3) offset

The single action discs were common when power was limited to small tractors and horses. In order to do a sufficient job, they must be overlapped halfway. These discs tend to leave ridges because the two gangs of discs throw soil in the opposite direction.

Tandem discs which are the most commonly used discs for seedbed preparation have two rows of opposing gangs. The front units turn the soil outward and the back row turns the soil inward. A small ridge is left between the two front gangs. This, however, can be eliminated by a springtooth placed between the two gangs.

Offset disc harrows first move the soil in one direction and the second gang moves the soil back. These harrows are usually heavier and are more suitable for primary tillage. They are designed for tough ground and heavy trash conditions.

The disc blades are the work horse of the discs. A small blade of equal weight to a larger diameter blade, will penetrate much better. However, larger blades are better for cutting through trash. Many discs have a heavier gauge in front to compensate for the fast wearing of these blades. Some disc blades are notched to give better penetration, and to cut crop residue more effectively. These blades are more expensive. Some disc harrows only have the front set of gangs notched.

Many discs are rated on a weight per foot or weight per disc basis. A weight per foot will give a good comparison of overall weight of the unit where a weight per disc will better explain the penetration ability of the disc. Also, size and thickness of blade should be checked and noted in a comparison.

Scrapers are essential on discs if the unit is to be used in wet sticky soil or trash conditions. A scraper should be adjusted to touch the disc lightly. If improperly adjusted, a build-up of material on the disc will result.

In the operation of a disc, it is important to check the nut on the end of a disc gang and tighten it to the owner's manual specification. A loose nut will cause excessive wear and possible damage to the disc itself.

The angle of a disc gang usually ranges from 10 to 25 degrees to a line perpendicular to the line of travel. The sharper the angle, the deeper the cut which results in better trash covering and more power requirement.

Soil immediately below the disc blades will have a tendency to compact. This is even more evident in wet conditions where compaction can be severe enough to prevent root penetration.

In order to prepare a proper seed bed, it is important to leave the soil uniformly smooth and firm. Therefore, the disc must be level from side to side and from front to back. These adjustments can easily be made with the tractor linkage system.

Field cultivators and harrows do not compact soil as disc harrows do. Also, they do a much better job in controlling weeds such as couch grass especially if equipped with a sweep.

When operating in small fields and tight corners, the mounted 3 point hitch units are recommended. In a three point hitch unit, it is not desirable to use a gauge wheel for total depth control. A properly adjusted depth wheel should carry little weight when cultivators are at the desired depth.

As with the disc harrow, it is important to have the cultivator level. Also, speed greatly effects the tilth left behind by the cultivator. Speed will usually range between 5 to 8 km/h. When operating a cultivator and sharp turns must be made, the cultivator should be raised to avoid twisting, or breaking teeth.

The double curved springtine cultivator commonly referred to as the "S tine" cultivator, does an excellent job of breaking clods and pulling weeds as a result of its vibration action. These cultivators are relatively easy to pull and only require approximately 1.5 hp per tooth.

These cultivators usually have four bars on which tines are attached at 40 cm intervals, therefore giving an overall spacing of 10 cm. A 3 meter cultivator would require approximately 45 hp and can cover as much as 3 hectares per hour.

A trailing cultipacker on the "S tine" cultivator is a desirable feature. It provides additional levelling and firming of the seedbed.

The conventional springtooth harrow usually works at depths of 7 to 15 cm loosening and breaking clods. The springtooth harrow if set shallow and travelling in the direction of plowing will not drag up chunks of sod to the extent an "S tine" cultivator would in a freshly plowed field. Also the springtooth harrow is better than the disc harrow for stoney ground but will plug badly in heavy trash conditions.

On many farms, springtooth harrows have been replaced by the "S tine" cultivators because of their ability to penetrate hard ground and pull tough weeds.

High adjustment of the springtooth harrow is usually done by the angle of teeth along with the adjustment of running shoes. Most springtooth harrows have three rows for which the teeth are spaced 30 cm apart.

Power harrows utilize tractor engine power through the PTO rather than through traction. This can be an advantage in wet fields.

Precision Seeders

In selection of a precision seeder, several factors should be kept in mind. A grower with a number of crops must consider the seeder's adaptability to these crops. On many farms, the speed of operation is also an important factor. The quality of work, ease of operation and adjustment are important factors but most of all, there must be service and availability of parts from a reputable dealer.

A precision seeder is designed to give accurate placement of individual seeds. If these units are to give satisfactory results to the operator, they must be handled with care and respect.

Before the beginning of a season, a seeder should go through a complete maintenance overhaul in the workshop. All moving parts should be checked for wear and ease of movement.

Preliminary adjustment such as seed placement (depth and spacing), should be completed along with press wheel tension etc. Most units can be shop calibrated and then again recalibrated in the field. It is important that the operator of any seeder completely understand his unit and read his operator's manual so that small problems can be avoided. In many cases, a small problem can greatly effect the performance of the seeder.

The seeder just be cleaned on a regular basis to ensure that the mud or soil particles are not altering performance. Also, the seed chamber should be clean of dust and other foreign particles. These seeders are precision units and require careful, accurate adjustment if satisfactory results are to be obtained. In two-row units or larger, it is necessary to have the units running level so that equal pressure on the soil is exerted by each unit. Three-point hitch tool bars will require sway bars on the tractor to ensure proper seed placement. These seeders require precision operation along with precision sized seeds.

The performance of a precision seeder is greatly affected by soil conditions. It is important to have the seed bed in optimum condition. This will also minimize the affects of soil crusting. Varying soil conditions such as moisture will require minor adjustments to the covering mechanism and depth controls.

The most common precision seeders in Nova Scotia at present are the Stanhay and Webb seeders. An evaluation of these two, as well as three others has been done by the Engineering Branch of the New Brunswick Department of Agriculture. For a copy of this report and further information contact your machinery engineer or vegetable specialist.

Although this section has dealt with tractor mounted precision seeders, for the smaller operator hand pushed models are available.

Non precision seeders such as the Planet Junior and plate-type planters are still used extensively as hand pushed models or tractor mounted. Plate type models have an advantage for large, irregular shaped seeds such as corn, cucumber or squash.

Chemical Application

Chemical application to vegetable crops is essential to the production of the top quality products demanded by today's educated consumer. It is a recognized fact that consumers are becoming more aware of the use of agricultural chemicals. It is therefore essential for the producer to effectively apply the necessary chemicals in the correct amounts so as to obtain the desired level of pest control at the lowest application rate and product cost.

The first area in which chemicals are applied to vegetable crops are in the form of fertilizer materials. Fertilizer product may be applied broadcast, pre-plant incorporated in the granular form using the common spin-type applicator, pneumatically or via gravity feed systems. Similarly granular fertilizer material may be banded at planting or side-dressed to the vegetable crop later on in the growing season. Many producers top-dress their crops which is usually effective, however, generally is an inefficient means of supplying nutrients to the crop. Fertilizer in the liquid form is available in some areas and allows producers a means of improved application accuracy. Also fertilizers may be fed to growing crops via irrigation systems (Fertigation).

Chemical pesticide application is restricted almost entirely to liquid application utilizing the traditional hydraulic spraying systems. The application of pesticides remains an exacting science which is continuously being updated, especially in the area of nozzles. Generally, "flat fan" nozzles are utilized in the application of herbicides and insecticides. Hollow-cone nozzles are most effective for application of fungicides. Nozzle tips are available in a wide variety of materials, including hardened stainless steel, thermoplastic and brass. The relative advantages and disadvantages of the various nozzles are many. For the purpose of this publication, it is satisfactory to suggest that further research can be obtained by reviewing the publications listed at the end of this section. A comprehensive understanding of the crop, pesticide and application procedure is required in the selection of the proper and most efficient nozzle.

Controlled droplet application (C.D.A.) or rotary atomizers were introduced for low volume applications of liquid carrying herbicides. Good weed control can be obtained with low volumes of product when these applicators are properly used; however swath displacement by wind and poor canopy penetration of the spray remain to be effectively overcome by manufacturers. Research to date in many cases has not proven this to be a superior method of applying presticides.

There is a wide array of granular application equipment available to producers, however this product

form is not widely used in the Atlantic region, with the exception of granular insecticide.

The granular insecticides are generally applied at the time of planting with a side dressing unit. Many growers find that they can obtain protection with the granular application throughout the growing season.

Transplanters

New technology is developing in this area, making faster transplanting possible with less transplanting shock in certain crops such as cabbage and cauliflower. With these crops, herbicides have not been effective. With improved transplant methods coupled with effective cultivation, crop quality and yields have increased, with a minimal increase in production costs.

Harvesting

The harvesting phase of vegetable production is crucial to the financial success of the operation. Negligence in the operation can quickly change top quality produce into worthless culls or animal feed. The machinery used for harvesting tends to be specific to each crop. To detail every unit available is beyond the scope of this publication. However, an attempt will be made to touch on some of the principles used in mechanically harvesting a crop.

Most of the leafy vegetable crops grown in Atlantic Canada are still harvested by hand, and require considerable development to assist in mechanization of harvesting. The initial step into mechanization of this type of operation is the consideration of harvesting aids that allow the picker to place the product on a conveyor system which delivers it to a point in the system for centralized packing. For certain types of vegetables, "wings" on the machine will allow the pickers to sit or lie down so that a more comfortable position can be attained.

The harvesting of brussels sprouts has been semi-automated. A machine will cut the sprout stem off and transport it to a stripper. However, it must be manually fed into the stripper head where the sprouts are removed.

The mechanization that exists in vegetable production to date is predominantly in root crops such as carrots, rutabaga. Here, deleafing/topping and harvesting have been, or can be mechanized. For example: a sugar beet topper, equipped with rubber flails, makes a good topper for rutabagas. A single row potato harvester equipped with flighted conveyors will work well in rutabagas.

The primary machine used for carrot harvesting has been the F.M.C. or "Scot viner". The crop is loosened by a lifter which goes under the crop, and is picked up by belts which grab the tops and deliver the carrots to the "topping bars" which squeeze together to separate the carrot from the top.

One serious impediment to any type of harvester which uses the top of a plant to lift it, is frost. If frost kills the tops, then some other method of lifting the crop must be used. This can be a spade or finger wheel device.

If root crops are to be stored in bulk, every effort must be made to remove all foreign material from the crop as it goes into storage. Green or leafy material that gets into the storage can and usually do start pockets of deterioration of the stored crop. Dirt and leaf removal equipment is essential.

Washing and Packing

Root washers are used extensively in Atlantic Canada as an important piece of post harvest equipment for vegetable crops, both fresh and processing. Barrel type washers are the most common type, which uses the principle of agitation of the crop, which is immersed or partly immersed in water. Wiremesh, stainless steel or wood-slat barrels are partly immersed in a tank of water. The roots are tumbled repeatedly by the rotation of the barrel. The roots pass slowly through the barrel by a combination of barrel slope, angled flights, and pressure from fresh roots being fed in, and are removed on a slatted conveyor. At this point, a final water rinse is incorporated from overhead sprays. Each vegetable crop has specific needs, so for further information on washing, you should consult your vegetable specialist and/or extension machinery engineer in your province.

Size graders are an important facet of vegetable preparation in many pack houses. Sized conveyor chains, oscillating screen graders, diverging roller graders and weight graders are four methods whereby the crop can be divided into as many sizes as desired, or is economical. Again, each crop is specific in its equipment needs.

In smaller packhouses, trimming tables and conveyors are extensively used. In the larger packhouses, automatic or semi-automatic packaging equipment is necessary. Mainly poly bags, paper bags and netted packs are produced. In the future more overwrapping equipment will probably be used for specific vegetable crops.

Efficient and economic vegetable production depends on the use of an appropriate balance of equipment, especially in the harvesting, washing and packaging of vegetable crops. Growers should consult with their vegetable specialist and machinery engineer for their recommendations. Usually, travel to other production areas to tour working vegetable operations is required before investments are made in new equipment.

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VIII Marketing Management

The application of modern marketing management practices in commercial vegetable enterprises has become increasingly sophisticated in the 1980's, ranking equally in importance with variety selection, cultural practices and good pest management. Assessing market potential is now among a grower's first concerns when considering a new crop or expanding production, instead of an after-thought when the crop is ready for harvest.

More than just selling, marketing encompasses all of the activities involved in moving a product from producer to consumer. In the case of most vegetables, marketing can include: cooling, grading, packing, selling, pricing, shipping, warehousing, redistributing, retailing, sales follow-up, market research, promotion, and it can be argued that harvest and storage decisions are also marketing functions.

Current marketing theory advocates building the correct "marketing mix" for a product in a specific market, that is, in following the so-called "Four P's" of marketing, putting the **Product** in the right **Place** at the right **Price** with the most effective **Promotion**. Of course, in an industry as varied as the vegetable sector, each product, on each farm needs its own "marketing mix" and professional advice, consultation with buyers and marketers and the grower's own experience in order to effectively market the product for the best return.

Market Assessment — The First Step

Many marketing programs in agriculture are "product-driven", that is the marketing effort must be tuned to fit the product in hand. This is often an uphill battle, trying to "push" product on the market that may be in over-supply, or in the wrong form, or for which there is no demand. The opposite approach is generally called "market pull", seeing (or creating) an opening in the marketplace and filling the need with the product the customer wants, when, where and in whatever form or package he wants it.

Finding or recognizing market opportunities is the key to capitalizing on them. Growers should consider the market outlook for a crop before undertaking the investment of producing it. The produce industry by nature seldom has iron-clad guarantees of markets or good prices; but reasonable assurance of a market for your product can be found through sound marketing management. When considering a new crop, expanded acreage or a new market, established growers should:

A) meet with distributors to determine their requirements.

B) understand the competition now supplying the market (sources, quality, supply, prices)

C) objectively assess their ability to profitability produce a marketable quality product — does it fit your farm enterprise? Will the crop get the necessary attention?

Market-Research — Gathering The Facts

Information Sources —

A wide variety of marketing information is available to Atlantic vegetable growers to assist in production and marketing decisions. The Nova Scotia **Vegetable Marketing Handbook** includes data on vegetable consumption, Atlantic Canada foreign imports, wholesale prices, storage holdings and other information. A number of up-to-date marketing studies have been completed under agricultural development programs in each province, including assessments of the foodservice trade, fresh vegetable market requirements, reports on investigative travel and a number of specific market feasibility studies. These reports are public information and are available on request from the local specialists. In addition, short and medium term market information is available from marketing branches of the federal and provincial departments of agriculture to assist selling decisions and to follow recent trends. Private sector sources include publications like "The Packer" and "Produce News" which carry news of interest from the U.S. produce industry, and other services such as the "Pro-Net" computer database with timely market information from the United States.

Market Structure — Atlantic Canada

The organization of the wholesale/retail produce trade in the Atlantic region has changed dramatically in the past decade. During the period, supermarket chains have increased market share to more than 70% of retail fresh produce sales with an attendant decline in independents. The trade has also "vertically-integrated" to the wholesale level such that virtually all large produce wholesale firms are now owned by retail groups or vice-versa.

Buying practices and produce requirements of the chains and the smaller independents that serve them have changed as these firms have expanded, and local growers must meet the delivery, quality and packaging standards of the international produce trade. While some firms allow, or encourage, direct delivery of local produce to individual stores, the trend is toward greater head office control of buying and ordering,

with deliveries either to central warehouses or to specific stores. In some cases, where firm grower/buyer arrangements exist, buyer trucks may pick up loads at the packinghouse.

The foodservice sector, with a wide variety of large and small operators, varied menus, ownership and control, remains under-served by local produce. The industry, ranging from individual, locally-owned establishments to fast food chains and large hotels, has exacting specifications depending on the type of menu. Sources of fresh produce vary and some small market gardeners have been able to supply local restauranteurs on a seasonal basis while penetration of the "fast food" component has been spotty at best, due to limited local supplies and inability to provide consistent delivery. All major wholesale firms compete fiercely for foodservice business and one Halifax firm specializes in this trade. The foodservice market requires frequent deliveries, often small quantities and, depending on menu, specialty items. Institutions such as hospitals, military and penal establishments have unique needs with cost control and nutritional balance as prime concerns. Suppliers to government-run institutions must tender bids, usually on a monthly basis, for supply contracts on specific items.

Competition

Consumers in Atlantic Canada have come to expect a constant supply of a wide variety of fresh produce items all year round, and, as a consequence, the trade has become accustomed to dealing in the international marketplace. Local producers, therefore, must market vegetables of comparable quality and value in order to secure a long-term share of local markets.

Atlantic Canada, with a relatively small population dispersed over a large area, is a difficult market to serve with both local and imported produce. Transportation costs are above average and there is frequent need to assemble mixed loads, as is the case with much of the U.S. produce sourced through the Boston Terminal Market and with central Canada vegetables in season. The region is sensitive to small changes in volume, regardless of source, and short-term gluts can lead to sharp price drops which are slow to recover. Conscious of this volume/price sensitivity, experienced local producers have begun scheduling planting and harvesting more carefully and undertaking expansion, with some caution.

Consumer Trends

In analyzing the complexities of consumer trends we find a number of developments which create "market pull" for fresh vegetables through increased consumer demand. There is a general trend among North American consumers toward greater concern for health, nutrition and personal well-being. Vegetables are perceived to be an essential part of a balanced diet and many items, such as brassicas, have seen tremendous increases in consumption.

Consumers' interest in a healthful lifestyle translated readily into greater consciousness of the nutritional value of fresh produce. An example is the generally-accepted concept that a high-fibre diet reduces the risk of certain types of cancer and that cole crops in particular, seem to reduce cancer risk. While fresh vegetable consumption has increased through nutritional awareness, there is also growing concern about food additives, pesticide use and food safety.

The trend toward greater participation by women in the workforce has perhaps had the greatest effect on food consumption patterns. The lifestyles of two-income families are characterized by careful time management, convenient meal preparation, more away-from-home eating, more food purchasing by males and teens, and an interest in more elaborate "leisure meals" and exotic foods associated with higher household income.

Market Planning

Having assessed the market opportunity for a particular crop, the grower should then make sure the various **product, place, price** and **promotion** parts of the marketing mix discussed earlier are in place.

There is no dividing line between production and marketing in vegetable growing. **Timing** of harvest can be crucial, especially in a small market like Atlantic Canada, and is controllable, to varying degrees by seeding/transplanting dates, variety selection and the use of plastics and mulches. Similarly, **quality control** must begin at seeding time, **not** harvest time, in order to produce a competitive product that will encourage buyers to make repeat orders. The technical aspects of fertility, pest management, **post-harvest handling** and other specialties are dealt with separately in this publication. The marketing benefits of good post-harvest practices for example, are tremendous, and, although growers have made substantial improvements in both equipment and practices in the past decade, buyers have had difficulty working with the more perishable locally-produced items in their distribution systems due to improper cooling, variation in pack sizes and other problems.

Packaging has long been a concern to both shippers and distributors of fresh produce and the search for the "ideal" package continues. In general terms the package must satisfy the market being serviced and the type of produce to be contained. Growers should consult with **customers** and **packaging manufacturers** or suppliers well in advance of harvest/shipping time to make sure the right choices are made and the materials are on hand when they're needed.

A partial checklist to aid in packaging decisions would include:

1) Type of product(s) to be packed.
2) Customers' preference — bag
— carton
— tray
— other
3) Packing conditions
— field packing or damp product — need waxed carton
— top icing or ice injection — affects carton design

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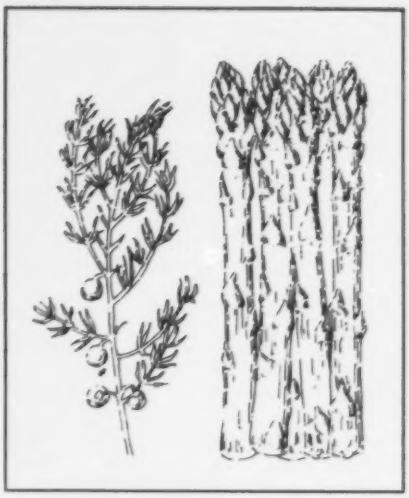
Asparagus



Introduction

Asparagus is a member of the Liliaceae (lily family) and has separate male and female plants. *Asparagus officinalis* is a perennial crop which is productive for fifteen years or more after establishment. It originated along the seacoasts of Europe and Asia and has been cultivated for over 2000 years.

Asparagus is adaptable to temperate regions where low temperature or drought give the crop a rest period. The minimum temperature for germination is 10°C. The optimum range for germination is 16-30°C. The optimum temperature for germination is 24°C. The crop does well under cool season conditions; however, the rate of growth is very temperature sensitive. The length of time required for the asparagus shoot to grow from 10cm to 25cm varies from 5.3 days at a mean daily temperature of 11°C to 1.9 days at a mean temperature of 25°C. Rhizome buds form at temperatures between 16 and 32°C. This plant requires a good water supply but will not tolerate wet soils. Asparagus is frost sensitive so areas subject to late spring and early fall frost, should be avoided if high yield is to be obtained. Dormant asparagus crowns are rarely harmed by winter cold.

The preferred soil is deep, reasonably free of stones and gravel, loose, a fine loamy sand to sandy loam with reasonable organic matter. Good drainage is essential. Heavy soils such as clay loam should be avoided. A site should not have had asparagus production in the past. This crop requires a rooting depth greater than 1.5 M.

The first asparagus harvest occurs, in the spring of the third year from planting (1 year old crowns). A potential yield in the third year would be 1000 kg/ha, in the fourth year 2000 kg/ha, and in the fifth and succeeding years 3000 kg/ha. Recent cultivar trials show large variations between cultivars in yield potential during the first few years but no long term data is available.

Presently asparagus is a specialty crop in the Atlantic area and small amounts are delivered to roadside markets, restaurants and retail stores. However, there is potential for increased fresh market consumption and also enough land resources for processed asparagus production.

Nutrient Content: Very good source of Vitamin A and potassium. Good source of Vitamin C. Contains small amounts of other nutrients including iron. Very low in sodium and calories. 3 to 4 spears provides 10 kilocalories.

Crop Establishment

Seed harvested from strong, productive parent plants will produce plants that are more productive and less susceptible to disease than those grown from seed taken from weak plants. Seed of older varieties are continually being re-selected for increased performance. Many high yielding F1 hybrid male cultivars are on the market. Male plants are usually higher yielding than female plants within a variety. (See Pub 1400A)

Seed Treatment — Asparagus seed is soaked for 3 - 4 days at 30-35°C before planting. This soaking softens the seed coat, swells the seed, and starts the germination process which results in earlier emergence of up to one week. There is no advantage if seeding is done into a dry soil.

Seeding/Planting — Asparagus seed should not be planted deeper than 2.5 to 4 cm, depending on soil type and seeding date. Choose a light, well drained sandy loam seedbed with pH about 6.6 and free of perennial weeds. Sow 1 kg of seed per 1000 square meters of seedbed, to produce approximately 25,000 crowns, enough for 1 ha, after plant selection. Select 1 year old crowns the following spring, weighing 30-50g.

Permanent field spacing of the crowns should be in rows 1.25 to 1.75 m apart with 30 to 45 cm between plants. This requires approximately 20,000 plants per hectare. Lift 1 year old plants in early spring. Discard small crowns (under 25 g) and crowns with close-spaced, narrow buds. Grade plants so that similar sized crowns are planted in the same field. Plant in furrows 15 to 20 cm deep, shallower on heavier soils. Spread roots as much as possible, place buds upward and cover with not more than 5 cm of soil. Fill the furrow gradually by cultivation during the first year. Good weed control will maintain a high plant population and vigorous growth.

Fields can also be planted with asparagus seedlings that are 8-12 weeks old. Seeds are planted individually in blocks, modules (large) or flats in February. Transplants are planted to the field in late May. Direct seeding may be possible in some situations.

Crop Management

Establishment — It is essential to maintain vigorous healthy fern growth especially during the first two growing seasons. Weeds must be kept under control throughout the growing season or crown growth will be restricted.

Mature Stands — After the last cutting of the season, plantings are usually disked lightly for weed control and to incorporate fertilizer. Then the fern is allowed to grow for the remainder of the year.

Asparagus fern growth should not be removed while it is still green as it supplies food to the roots. Ferns should be left to trap snow which protects crowns from low temperature winter injury. The fern can be cut with a rotary or flail-type mower early in the spring and lightly disked into the soil. This can provide 10 to 15 tonnes of organic matter per hectare. All cultivation for fern disposal, weed control and fertilizer incorporation should be shallow and kept to a minimum.

In a vigorous stand the harvest period in year 3 is 1 to 2 weeks, in year 4, 3 to 4 weeks and in year 5 and thereafter 5-7 weeks. Harvest should only proceed if the spear size is large. When the size starts to decrease then harvest should stop. Over harvesting results in small diameter ferns which initiate small buds which give rise to small spears the next harvest season.

Nutrition

ALL ADDITIONS OF LIME AND FERTILIZER OR MANURES SHOULD BE BASED ON RECOMMENDATIONS FROM A SOIL TEST. WHEN TEST RESULTS ARE NOT AVAILABLE THE GENERAL REQUIREMENTS FROM TABLES 1-4 OF THE SOIL AND WATER MANAGEMENT SECTION OF THIS GUIDE MAY BE FOLLOWED.

Asparagus responds to manures. Use it prior to planting crowns and with annual top dressings. Not only does it contribute nutrients but also significant organic matter to the soil. Caution should be used with poultry manure as excess nitrogen may be detrimental.

Lime — Lime should be applied to maintain the soil pH in the range 6.0-6.8. Asparagus is particularly sensitive to soil acidity which is a frequent cause of crop failure.

Nitrogen — The needs for crown production are lower than in established fields. For crown production half the nitrogen is applied at planting time and half is side-dressed in August depending on weather conditions and the vigor of the stand. For new plantings all of the nitrogen is applied preplant. For established plantings apply half the nitrogen before harvest and half the nitrogen immediately after harvest.

Phosphorus — This nutrient is important to crown producing fields and new plantings. It is important to band phosphorus in new plantings to ensure the stand will be well fertilized in this element as it cannot be effectively applied later. Approximately 450 kg of 0-20-0 mixture should be banded with the crowns in addition to the recommended broadcast applications.

Potash — Asparagus has a relatively high potash requirement and an additional sidedressing in established fields in early August may increase yields the following year.

Micronutrients — Asparagus has a high *boron* requirement. If a deficiency is suspected apply a soil spray of 1.75 to 2.25 kg of actual boron per hectare or apply a boronated fertilizer. *Sulfur* may be beneficial on sandy soils with low organic matter.

Application Method — Generally in established fields nitrogen, phosphorus, calcium and magnesium are broadcast with shallow incorporation. On newly established fields a wide band over the row may be used.

Pests and Pest Control

Weeds

Perennial weeds such as quackgrass, must be completely eliminated during the year prior to the planting of asparagus crowns or seeds. During the establishment year use the "stale seedbed technique", whereby emerged weeds are chemically "burnt-off" with a post emergence herbicide prior to crop emergence. Additionally herbicide(s) that control germinating weeds (preemergence) can be applied before and after spear emergence.

Established asparagus can be disked in the spring and then treated with one of several residual herbicides prior to spear emergence. Alternatively emerged weeds can be treated with a postemergence "burnoff" treatment and then a residual herbicide prior to spear emergence. A second treatment of herbicide should be applied after the last harvest to provide weed control through the summer.

Diseases

Fusarium Diseases (fungi)

Characteristics — Growing stalks are stunted, yellow and may wilt. Fern growth is also yellow and stunted. Crowns, roots and stems may show discoloration of vascular bundles and varying amounts of decay.

Control — Avoid replanting land which previously grew asparagus. Treat seed and crowns before planting. To avoid injuring the crowns, do not cultivate deeper than 10cm.

Rust (fungus)

Characteristics — This is a potentially serious foliage and stem disease which causes elongated orange red powdery areas on stems and foliage. All commercial cultivars are susceptible to rust.

Control — Disease control is achieved only with thorough spray coverage on a regular schedule once the disease is observed. This spray must protect the new foliage as it grows, before rust spores can land on it and germinate (a 7 - 10 day schedule from late May to late August).

Insects

Spotted Asparagus Beetles

Characteristics — The adult beetles are 6mm long and reddish-orange with 6 black spots on each wing. They feed on the young shoots and fronds. The orange larvae feed inside the berries.

Control — Leave uncut rows, in the spring, to serve as traps for the beetles. When temperatures are above 21°C and the beetles are seen on the uncut rows use one of the recommended chemicals.

SPECIFIC CHEMICAL CONTROLS FOR THE VARIOUS CROP PESTS DISCUSSED MAY BE FOUND IN THE SUPPLEMENT TO THIS GUIDE, A.P.A.S.C.C. PUBLICATION 1400A, "A GUIDE TO CULTIVAR SELECTION AND CHEMICAL PEST CONTROL FOR VEGETABLE CROPS."

Harvesting and Handling

New plantings can usually be harvested for about 2 weeks in the spring of the third year after field setting. Harvest by cutting or snapping spears at ground level when 18 to 25 cm tall. In established plantings, the harvest season is from about May 20 to early July. Harvesting should be terminated early if emerging spears are too thin to meet the grade standards.

Storage and Conditioning

Asparagus is usually not stored. It can be kept 3 to 4 weeks when hydrocooled immediately after harvest to storage temperature, (0°C). The relative humidity requirement for storage is 95%. To prevent excessive moisture losses, the bunches are set in shallow pans of water. A moisture loss of 3 - 6% will markedly affect the quality. The average freezing temperature of asparagus is −1°C. At 0°C half the initial sugar in an asparagus spear is lost after 2 weeks of storage, at 10°C it takes 1 week, at 20°C, 2 days, and at 30°C only about one half day.

In transit, controlled atmospheres (CA) are being used increasingly. When the temperature can be held between 0 and 3°C, then 12 ± 2% carbon dioxide and normal oxygen makes an acceptable atmosphere; at higher temperatures the carbon dioxide should be reduced to 7 ± 2%. Butt ends are wrapped in water holding materials with stalks held upright.

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Beans (Snap)

Introduction

Snap Beans (green or wax) are a member of the Leguminosae (legume family). In the species *Phaseolus vulgaris*, are also dried beans which are harvested for baking beans. There are over 200 different types of beans originating in various parts of Central America which have been cultivated for over 7000 years. The plant may be a bush, a half runner or a pole bean. This crop is botanically described as an annual twining vine. Bean flowers are self pollinated. Snap bean cultivars differ from dry bean cultivars by having thicker walled pods. These vary in color with green, yellow and purple being the ones most commonly grown. Commercial cultivars are mostly determinate (non climbing). Flowers appear simultaneously and pods tend to mature together — an advantage for mechanical harvesting and where single heavy pickings are required for the fresh market. Some cultivars tend toward multiple branching and vining causing flowers and pods to develop over a period of time, allowing for several pickings. In 1894 the first stringless bean was introduced.

Snap Beans are adapted to both temperate and tropical areas where there is a greater frost free period than 50 days and soils are warm enough to allow seed germination. Beans are frosted at −1°C to −2°C. The minimum temperature for seed germination is 15°C, with a maximum of 35°C and an optimum range of 15-30°C. Seed rot is a problem at lower soil temperatures and is further aggravated by wet soils. Best crop growth occurs at 18-23°C with a minimum of 10°C and a maximum of 32°C. Beans do well under warm conditions and date of maturity can be reliably estimated using degree days above 5°C. Temperatures of 32°C will cause poor pod set. Snap beans are sensitive to soil moisture stress especially at the time of flowering.

Beans should be planted in well drained soils with good aeration and soil borne diseases have to be kept in check by good rotations. A range of soil textures are suitable to the crop but sandy loams are best suited for early crops and then loams for later production. The soil should be well supplied with organic matter. Organic soils are not recommended as they promote excessive vegetative growth. Avoid growing on steep slopes since the crop does not offer much protection against soil erosion.

Snap Beans are available from late July to late September for both the fresh and processing markets. With tunnel house production this season could possibly be extended. Harvest is approximately two weeks after bloom.

An average yield for snap beans is 4400 kg per hectare. High yields vary from 6600 - 17,600 kg per hectare.

Snap beans are an important crop in the Atlantic Area mainly due to the processing industry. Relatively few beans are grown for fresh market use and most of this crop is picked by hand labor.

Nutrient Content: Good sources of Vitamin A, potassium and folate. Contains several other nutrients in small amounts. 250 mL (1 cup) contains 32 kilocalories.

Crop Establishment

Seed Treatment — Chemical seed treatments should be used to protect seeds from maggots, wireworms and seed decay organisms. Seed treatment should not be done more than 3 months before sowing. See Publication 1400A for specific recommendations.

Innoculation of seed with nitrogen fixing bacteria should be done on "new" fields with the use of a dust containing the proper rhizobium bacteria.

Beans should be handled gently as cracked seed coats and cotyledons decreases germination and seedling vigor.

Beans with a dark colored seed coat are generally more hardy and will germinate better in cold soil conditions.

Seeding/planting — Seeding should be delayed until the cold weather is past, the soil has warmed (to 15°C) and the danger of frost at emergence is past. Wet, cool weather will delay germination, causing decay of seeds and increasing injury to seedlings by maggots and root rot organisms.

In heavier soils, seeds should be seeded no deeper than 2.5cm, while in sandy soils up to 4 cm is preferable. Sow as shallow as soil moisture levels permit. Planting in wet soil must be avoided because crusting of the soil and seed rot may occur reducing germination and vigor.

Typical Spacings and Plant Population Recommendations in Snap Beans

Desired Row Spacing (cm)	Plants Per Meter of Row	Approximate Seed Rate Per Hectare
90-95	20 to 26	80 kg
45, 50 and 60	17 to 22	100 kg
20-25	10	110 kg
15 to 18	6 to 8	165 kg

Closer row spacings will result in increased yields. In some fields gray mold and white mold disease losses are greater with narrow rows. Wider row spacings are suggested for fresh market production for either mechanical harvesters or hand pick. Narrow rows should be used for processing beans when proper harvesters are available.

Crop Management

Cultivation — preplanting soil preparation and adequate herbicides are recommended so that cultivation of the bean crop is not necessary. Bean roots, although penetrating the soil for up to 1 1/2 meters, are located mainly in the top 20 cm of soil. If cultivation is necessary it should be early in the life of the crop and as shallow as possible. It should cease after bloom and never be done when the leaves are wet, because of the danger of disease spread.

NUTRITION

ALL ADDITIONS OF LIME AND FERTILIZER OR MANURES SHOULD BE BASED ON RECOMMENDATIONS FROM A SOIL TEST. WHEN TEST RESULTS ARE NOT AVAILABLE THE GENERAL REQUIREMENTS FROM TABLE 1-4 OF THE SOIL AND WATER MANAGEMENT SECTION OF THIS GUIDE MAY BE FOLLOWED.

Beans require a highly fertile soil but do not, however, respond rapidly to direct soil applications of fertilizer. Heavy applications of manure are not recommended for beans as there may be excessive vegetative growth and a higher risk of seed corn maggot injury.

Lime — Lime should be applied to maintain the soil pH in the range 6.0 - 6.8.

Nitrogen — Snap beans have a low requirement for nitrogen since it is a legume crop. If phosphorus and potash levels are high no nitrogen may be required. Side dressing of nitrogen is only recommended following heavy rains, if foliage suggests a nitrogen deficiency. Extra nitrogen may help alleviate yield reductions caused by bean root rots.

Phosphorus — Banded phosphorus is necessary at the time of seeding, even at high soil phosphorus levels.

Potash — This element is best broadcast and incorporated into the soil prior to planting either as muriate of potash or manure. If banding potash do not apply more than 60 kg per hectare of actual nitrogen and potash combined.

Sulfur — Application is suggested on sandy soils with low organic matter which have been intensively cropped (use gypsum).

Magnesium — Beans are sensitive to deficiency of magnesium so a fertilizer containing MgO should be used where magnesium deficiency is suspected.

Micronutrients — Beans are sensitive to excessive residues of *boron* especially on soils with a low pH (under 6). *Zinc* deficiencies may be a problem as it is has been reported on other crops in the Atlantic area. Watch fields which are intensively cropped with low organic matter and not receiving applications of manure. *Manganese* deficiency is a problem when the pH is over 6.8. One or two foliar sprays of Magnesium Sulphate may be required to correct this problem. Use manganese sulphate at 1 kg of Mn per hectare in 1000L of water per hectare (also use a spreader sticker).

Application Method — All fertilizer should be broadcast and disked in or (preferably) banded 5 cm below and 5 to 7 cm to the side of the side of the seed row.

Pests and Pest Control

Weeds

There are several effective preplant incorporated, preemergence and postemergence herbicides available for use on beans. Preemergence treatments provide good control of annual broadleaf weeds. When a heavy annual grass infestation is anticipated a preplant incorporated treatment should also be used. Postemergence treatments are available for both grass and broadleaf weed control. The timing of postemergence treatments is critical for the control of some species and control may be poor if applications are not properly timed. Care must be taken to avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur.

Diseases

Anthracnose (fungus) and Bacterial Blights

Characteristics: Signs of anthracnose usually appear on the lower leaf surface along veins which show a brick red to purplish red discoloration. Lesions may also appear on stems causing them to break. On the pods, the disease appears as small brown specks or rusty brown spots. As the spots enlarge, their centers become sunken and turn brown. Under humid conditions, masses of pinkish spores appear on the lesions. Seeds obtained from heavily infected pods show brown to light chocolate colored spots on the seed coat.

Symptoms of bacterial blight appear on leaves as water-soaked or pale green spots or groups of spots surrounded by a narrow or wide greenish yellow halo. The spots may turn brown and dry and leaves may

shrivel and die. Water-soaked spots may appear on pods and combine to form blotches of reddish brown discoloration. Bacterial blight becomes progressively more severe as beans approach maturity.

Control: The causal organisms over winter in seed and plant debris. Do not use home-grown seed. Purchase disease-free snap bean seed. Practice a 3-year crop rotation. Do not cultivate or harvest when plants are wet. Applications of fixed copper will reduce the spread of bacterial blights. Rogue and destroy affected plants. Do not spread bean refuse or manure containing bean refuse on land intended for beans in the next three years.

Sclerotinia White Mold and Gray Mold (fungi)

Characteristics: Gray and white cottony mold which causes a watery softrot on plants, bean pods and stems, in which, hard black bodies are produced. This disease spreads rapidly after harvest. Infection starts on the flowers and spreads from there to the other plant parts.

Control: Plant on well drained soil not recently used for beans, lettuce, peas, tomatoes, carrots, parsnips, cucumbers, celery, or cabbage. Practice a 3-year rotation. Serious losses result when susceptible crops are grown for several consecutive years. Do not apply excess irrigation. Cultivate and pick when plants are dry. Avoid fields with a history of *Sclerotinia*. Plow plant refuse down immediately after harvest. Applications of fungicides may be applied during bloom.

Root Rot (fungus)

Characteristics: The taproot shows various surface discolorations of reddish brown or dark brown and smaller roots may be rotted away.

Control: Root Rot is caused by a complex of several soil borne organisms. It is present in every soil and nearly all plants have some degree of root rot. In seriously infected fields long rotations of 6 years or more are necessary. Bean refuse should always be placed in areas where beans will not be grown. Any bean refuse left on the field should be turned under deeply by fall plowing. Plant only on well drained, well fertilized soils.

Common Mosaic and Yellow Mosaic (viruses)

Characteristics: Plants infected with mosaic show mottling and mosaic patterns in the leaves which appear as irregular light green areas mixed with dark green patches. The darker areas grow faster resulting in puckered leaves. Plants may also wilt and show dieback of tips and branches. Infected plants are dwarfed and produce only a few small pods.

Control: These seed-borne viruses are spread in the field by aphids. Grow mosaic resistant cultivars. Avoid planting beans next to sweet clover, red clover and gladioli from which aphids may spread mosaic.

Insects

Seed Corn Maggot

Characteristics: The adult seed corn maggot fly deposits her eggs in soil where there is an abundance of decaying vegetable matter, on the seed or plantlet. The larvae (maggot) of the seed corn maggot is 5mm long and pale in color. The damage is caused by the maggot burrowing into the seed, often destroying the germ. Damaged seed will either not germinate or produce a deformed plant.

Control: Plant seeds as shallow as needed in a well prepared seedbed. Early germination is necessary to get good plant stands and prevent injury. Later plants crops are not as susceptible to this pest. Avoid planting susceptable crops in fields very recently manured. Chemical sead treatment is essential. Good weather conditions are necessary to completely control the pest.

Two-Spotted Spider Mite

Characteristics: An occasional pest but when it does occur, can be serious. Leaves become speckled and then turn bronzed or brown. A fine webbing is produced on the underside of the leaves. The mites are microscopic in size. Usually this pest only becomes a problem under very hot dry weather conditions.

Control: A predator mite may help control the two-spotted spider mites, but may not control a severe outbreak successfully.

European Corn Borer

Characteristics: European Corn Borer larvae overwinter in corn stubble. By July they have become moths that fly mostly at night. A single female lays eggs in small groups of 20 to 40 on the underside of host plant leaves. The larvae hatch within a week and enter the bean pods. Several pods will be damaged by a single larvae before it stops feeding. This pest has not become a serious problem in snap beans but damage to baking beans seeds is evident after harvest.

Control: Plow down corn stubble in the fall. Avoid planting beans after corn in rotation or adjacent to corn in the crop year.

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Harvesting and Handling

Snap beans are currently harvested by hand for the fresh market or by mechanical harvesters (ie. multi-D type harvesters) for the processing market. The following is an example of processing grades.

Grade # 1 Green or wax Snap beans, sieve sizes of 1, 2, 3, & 4

Grade # 2 Green or wax Snap beans, sieve sizes of 5 +

Fresh market beans must be quickly moved from the field and cooled. These beans should be free of white mold as problems may develop during storage and transport of the crop.

Storage and Conditioning

Snap beans can be held 8 to 10 days if necessary at a temperature of 7 to 10 C and a relative humidity of 85% to 90%. Chilling injury occurs at temperatures below 4°C and russeting will develop upon removal from storage.

Bibliography

(See also General References)

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Smeltzer, G. and R. Delbridge. 1979 & 1980. Snap Bean Production Systems Evaluation. N.S. Dept. of Agriculture and Marketing, Kentville, N.S.

Beans (dry)

Dry beans are, as snap beans, a member of the Leguminosae (legume family). *Phaseolus vulgaris* is the species and only differs from snap beans in that the seed is used after it is mature and dried.

Commercial cultivars are "bush types" which have a concentrated bloom. They come to maturity in early September (110 to 120 days from seeding). Yields in dry beans range from 1000 - 3500 kg per hectare depending on the cultivar and the season.

Beans are harvested from mid September to late October. They are dried and then marketed on a year round basis. Most beans produced in the Atlantic area are of the large seeded type. These find markets at roadside stands and with direct deliveries to retail stores. There is no current production for processing or wholesale markets which are large markets in the Atlantic area.

Nutrient Content: Good source of protein. Provides energy, calcium and folate, as well as other nutrients to the diet. 250 mL (1 cup) contains approx. 220 kilocalories. Also, 250 mL (1 cup) cooked dried beans constitute a meat alternate from Canada's Food Guide.

Crop Establishment

In most cases certified seed is not available of the large seed cultivars. Purity of seed is needed to ensure uniformity of maturity at harvest time. It is also important to select well developed, well matured, uniform strong seed of sound vitality. Diseased seed will produce diseased plants which may infect the entire crop. Bean seed should be germination tested. Seed as early as possible (last week of May or 1st week of June).

See Beans (Snap) Section for further information on seed treatment, seeding/planting.

Crop Management

See Beans (Snap) section

Nutrition

See Beans (Snap) section

Pests and Pest Control

(For control of weeds, diseases and pests see under Beans (Snap)

Harvesting and Handling

Harvest when most pods are yellow and beginning to dry but before they start shattering. Unevenness of maturity can lead to problems of either shattering or abrasion, discoloration or disease of immature beans. Desicants can be used to enhance uniform drying and crop maturity. Beans are harvested by a bean puller; pulling beans in the morning, when pods are damp and tough, lessens shattering. Vines are windrowed for subsequent pickup and threshing with a specialized bean combine; the time between pulling and combining should be minimized to avoid discoloration.

Storage and Conditioning

Beans should be about 18% moisture at harvest. Special drying techniques using heated and/or unheated air have been developed. If beans are not sold at harvest they can be stored in an elevator or granary. If seed moisture is below 15% the crop is ready for marketing or storage.

Bibliography

(See also General References)

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Dry Bean Production — Principles and Practices (L.S. Robertson and R.D. Frazer, eds) Michigan State University Extension Bulletin, E-12512, August 1978.

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Beets (Red)

Introduction

Beets are a member of the Chenopodiaceae (Goosefoot family). *Beta vulgaris* L. also includes within the species sugar beets, swiss chard and mangelwurzel and the common weed lambsquarters. It is thought to have developed from *B. maritima* the seabeet which is native to Southern Europe. Red beets are annuals as cultivated or biennials if roots are grown for seed. It was not cultivated until the 3rd century AD and not developed until the 19th century by German and French breeders.

Beets are a cool season crop. The best quality and root color are obtained when the air temperature ranges between 10 and 18°C. Abundant rainfall, nitrogen fertilizer and high temperatures provide for rapid development which leads to white rings in the interior of the beet root. The minimum soil temperature for beet germination is 5°C, with an optimum range of 10°to 30°C, an optimum temperature of 30°C and a maximum temperature of 35°C. Beets require a cold period of 2 weeks at 4-10°C or longer to initiate flowers (bolting). This may happen when beets are planted early and we have a cold May and June. Beets will tolerate frosts and mild freezes.

Beets prefer deep friable, well drained sandy loams to silt loams. Coarse sands should be avoided unless irrigation is provided. High organic matter in the soil is desirable and will help ensure an adequate moisture supply. The beet has a fairly large root system extending downward in the soil 1 m or more unless restricted.

Beets are used for bunched greens, bunched roots, beet roots and by processors for many products. Beets may be directly sown or transplanted into tunnel houses for early greens or bunching beets. In the field the first plantings are in late April or early May for early greens or bunching beets. For processing, beets can be planted from early May to late June. Beet roots for processing and fresh markets are harvested mainly in September and October. A yield of 20,000 kg per hectare is possible.

The main markets for beet greens and bunched beets is roadside, farmers markets and direct deliveries to retail stores. Some product reaches the wholesale channels. The market for beet root is not a large market but it is significant. With storage the marketing season may be extended. Processing beet production is also significant. Beets then are marketed fresh from May till February (greens, then bunched roots, then roots and then stored roots).

Nutrient Content: Has two edible parts — roots and leaves. The root contains potassium and folate as well as some Vitamin C. A 250 mL (1 cup) serving provides 58 kilocalories. Beet greens are a very good source of Vitamin A & potassium. They also contain some Vitamin C, calcium, and folate. 250 mL (1 cup) contains 26 kilocalories. Beet leaves make good salad greens.

Crop Establishment

Seed Treatment — Beet "seed" is normally sold as a rough seed cluster containing one to three seeds. A number of types of monogerm seeds are available. In one type the cluster is ground, in the other type the polished seed is extracted, and in another type genetically monogerm seed is produced.

Seeding/Planting — Sow seed every 2 to 3 weeks to provide a continuous supply of bunched beet root. Beets reach market size in 6 to 8 weeks. Processing beets are harvested when the bulk of the roots are 5 to 8 cm in diameter usually 90-110 days after planting. Crops for storage should be sown about 10 weeks before harvest. Sow at a depth of 1 to 2.5 cm. Seed from 6 to 11 kg per hectare in rows 40 to 75 cm apart for market crops. Seed 15kg per hectare for processing crops to give 50 to 80 plants per meter of row.

Multiple rows or beds may be used to advantage with wider spacings for equipment. Thinning may be necessary if too many seeds germinate and the market is for early beets (for roots or bunching).

For early beets in tunnel houses or in the field, sow seed in the greenhouse 6 weeks before transplanting in late April or early May. Use monogerm seed so that 6 seeds are seeded in each module or peat block. In the field space plants 10 cm apart in rows 30 to 40 cm apart. Do not break the tap root when transplanting or deformed roots will result.

Crop Management

Since herbicides do not usually give complete control shallow cultivation may be necessary through the growing season as well as some hand weeding.

Irrigation may be applied to a field before planting to bring up the soil moisture level on sandy soils. Early beet root will benefit from irrigation prior to pulling. This aids in harvesting if the soil is dry.

Nutrition

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Manure — Well rotted manure may be used at 30 to 50 tons per hectare. Fresh manure with wood shavings or sawdust should not be used as this may aggrevate scab.

Lime — Maintain a pH of 6.2 to 6.8 in all parts of the field (on mineral soils). Over liming may induce minor element deficiencies and encourage scab.

Nitrogen — Moderate amounts of nitrogen are recommended at the time of planting (not to exceed 100 kg per hectare actual). Sidedressings may be applied once or twice during the early part of the growing season (4 and/or 6 weeks after planting). Excessive nitrogen may mean excessive top growth and white ringing in the beet root if weather conditions are favorable.

Phosphorus — Moderate levels of phosphorus are recommended in balance with nitrogen levels. Band a high percentage of phosphorus if possible.

Potash — It may be useful to plow down at least 50% of the potash. If the potash level of the soil is low some potash should be plowed down.

Micronutrients — *Sodium* (NaC1) has been recommended in many growing areas. It is most effective at increasing yields where potash levels are low on sandy soils. It would be best applied broadcast and plowed down before planting. Apply 275 to 500 kg of salt (NaCl) per hectare. If potash levels are high do not apply.

Boron — Severe problems may result from a boron deficiency. When the soil pH is above 6 boron is not readily available for plant growth. Apply 3-5 kg of boron per hectare (15-25 kg Solubor) over the row at planting when both crop nutrition and weed control are desired. Use the lower rate of boron where it has been used often on that field. Stunting may occur on soils with a pH below 6 and organic matters below 3%. Foliar sprays may also be considered as alternatives especially when the initial soil boron level is quite high. (Solubor at the rate of 5.5 kg per hectare applied in 225-560 Litres of water per hectare. A wetting agent should be added to the foliar spray.)

Manganese — Deficiencies of this nutrient may occur on soils with a high pH. A foliar spray of 6-9 kg per hectare of magnesium sulphate in 200-300 litres of water per hectare should be applied as soon as plants are large enough to absorb the solution. In the case of severe deficiency additional sprays may be necessary.

Application Method — Band phosphorus if possible. Broadcast and plow down potash and salt applications. Part of the nitrogen may be sidedressed.

Pests and Pest Control

Weeds

Perennial weeds should be eliminated prior to planting beets. Herbicides recommended for use on beets are sometimes not readily available at planting and therefore herbicide orders should be placed early. Care must be taken to avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur.

Diseases

Damping-Off (fungi)

Characteristics: Beets are very susceptible to damping-off. Fungi attack seedlings at soil level, causing them to topple over or attack seeds following planting causing seed decay and poor stands.

Control: The importance of damping-off control in beets is often overlooked. Seed can be treated with the appropriate fungicide before planting. Rotate with other crops, avoid wet soils and delaying planting until soil is warm will reduce the amount of disease.

Leaf Spot (fungus)

Characteristics: Caused by *(Cercospora)* it is characterized by spots that are brown to gray with distinct reddish-purple borders. The fungus overwinters in diseased crop residue or on seed and is spread by splashing water, insects, tools and implements, workers, and wind. High humidity and moderate temperatures promote disease development.

Control: Follow a 2-3 year rotation. Apply a fungicide at first symptoms of disease and continue as necessary.

Scab (bacteria)

Characteristics: This same bacterium causes potato scab. This disease produces corky spots on the surface of beet roots. pH levels above 5.2 help promote disease development.

Control: The bacteria can exist in the soil for many years. Avoid land known to be infested or droughty, land and fields where sawdust, wood shavings or ashes have been applied.

Phoma Heart Rot (fungus)

Characteristics: May cause seedling damping off, a distinct brown leaf spot which may lead to extensive foliage loss and a root decay.

Control: Follow a 2-3 year rotation. Avoid cold, wet soils. It is extremely important to ensure that the crop is well supplied with boron and sodium. Low levels of boron and sodium predispose the plants to attack by the fungus.

Black Spot (Boron Deficiency)

Characteristics: Causes scattered black lesions in flesh of root, sometimes with large black areas on root surface. Most prevalent in alkaline soils, high in calcium and is promoted by dry conditions.
Control: Apply boron with the fertilizer at planting.

Insects

Springtails

Characteristics: Springtails are minute, less than 4mm long, that may occur in enormous numbers on the surface of and in soil high in decaying vegetable matter and other damp places. They are often dark in color. They may cause severe damage to seedlings. The plant may regrow in an abnormal, puckered form.
Control: Leaf miner sprays will control them when applied at first signs of injury.

Leaf Miner

Characteristics: These insects can cause serious losses in beets to be used for greens. White eggs are laid in groups of 1 to 5 on the underside of the leaves. After hatching, the tiny larvae eats a slender, winding mine inside the leaf. The mine becomes wider as the maggot grows and may join other mines in the leaf. The maggot stage lasts 2 to 3 weeks. In 2 to 4 weeks, following pupation, adults (flies) will begin the next generation.
Control: Insecticides should be applied when mining damage is first observed. Two or three treatments at 10-day intervals may be needed. Early in the season, infestations may be suppressed by destroying infested crop residues and weeds.

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Harvesting and Handling

To inhibit sprouting, apply sprout inhibitor to storage beets, 4 to 6 weeks before harvest, when the tops are in good condition. Follow manufacturer's directions.

Storage and Conditioning

Bunched beets can be held 10 days to 2 weeks at 0°C, and a relative humidity of 90 to 95%. Late beets (topped) will keep 1 to 3 months under these conditions. They will wilt if the humidity is not maintained at a high enough level.

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Carrots & Parsnips

Introduction

Carrot (*Daucus carota*) and parsnips (*Pastinaca sativa*) belong to the Umbelliferae (the carrot family). This family includes other vegetables such as celery, celeriac, parsley and several herbs. Both carrots and parsnips originated in the Mediterranean area and were in use over 2000 years ago. Carrots (Queen Anne's Lace) in Southeast Europe and Afghanistan — parsnips in central and southern Europe. Both are botanically biennial plants which were first used as medicines and then became popular as food crops — parsnips in the 16th century in Europe and the orange carrot in the 17th century in Holland. The edible part of these plants is an enlarged taproot.

Carrots are grown in the tropics where high elevations give cool night temperatures and in temperate regions of the world. Optimum growing temperatures for these crops are 15-20°C with a minimum of 5°C and a maximum of 24°C. The minimum temperature for germination is 2°C with an optimum range of 10°to 25°C. The optimum germination temperature for parsnips is 18°C and carrots is 27°C. The maximum temperature for germination is 30°C and 35°C respectively. These crops therefore favor cool season conditions. Low and high temperatures reduce seed germination. Both carrot & parsnips foliage is affected by light frosts (−1.5°C) but is not harmful to the roots. Adequate moisture is necessary for good yields and quality. Parsnips usually overwinter well on sandy well drained soils. When seedlings with roots 6 mm in diameter or larger are subjected to cold temperatures (below 10°C) for a period of time flower initiation takes place. For early seeded carrots of susceptible varieties, bolting may occur in the Atlantic area.

A deep well aerated soil, free from stones and well supplied with moisture is required for the development of long smooth roots. Well drained sandy loam and organic soils are preferred. Seed germinates over a 2 week period or is restricted if a crust forms on the soil surface. The earliest seeds to germinate produce the largest roots. The seed bed also has to be prepared free of clods since hilling of cylindrical varieties is required late in the season to prevent greening or "sunburn". Planting on hills also increases the length of carrots. Soil compaction affects root growth and length. In compacted soil the taproot is conical in shape and the root is usually heavily furled.

Carrot harvest begins with the bunched crop in mid July. Roots for packaging are harvested starting in early to mid August. By September 1st carrot harvest is intensifying. By mid September harvesting of the storage and processing crops are in full swing. Carrots harvested from mid September to November yield a gross weight of 30,000 to 80,000 kg per hectare. Marketable yields average 20,000 kg per hectare (fresh or processed).

Parsnip harvest usually begins in mid September for fresh market and storage although some hand harvest may be done for roadside market sales in early September. Parsnip yields are 20,000 to 30,000 kg per hectare.

Carrot production in the Atlantic area is important due to a large fresh market and processing industry. It is a crop with a high per capita consumption and there appears to be some potential for increased consumption of both fresh and processed products. Parsnip consumption in this area is traditionally high and it is not anticipated there will be much increase in this market. Carrot growers usually produce some parsnips to make up truckloads and hopefully increase overall profits.

There may be some markets for speciality crops such as baby carrots (fresh and processing), large carrots for HRI trade, and parsnips for processing.

Nutrient Content of Carrots: One of our best sources of Vitamin A. One medium raw carrot supplies our daily requirement of this nutrient. It also contains other vitamins and minerals including potassium. 1 raw carrot contains 20 kilocalories. 250 mL (1 cup) cooked carrots has 47 kilocalories.

Nutrient Content of Parsnips: Good source of calcium, potassium and folate. Contains small amounts of other nutrients including Vitamin A and C. A 250 mL (1 cup) serving of cooked parsnips contains 186 kilocalories.

Crop *Establishment:*

Seed Treatment — Usually pelleted seed is purchased for use in precision seeders. High quality seed is essential for good germination and seedling vigor.

Seeding/Planting — Sow as early as the soil can be prepared. This is usually late April or early May. Soil moisture levels then are usually higher, there are fewer problems with crusting and generally better

stands result from early seedling. Late seeded crops may burn off if they emerge during hot dry weather.

The seeding depth should not exceed 0.6 to 1.2 cm. Deeper planting results in uneven or no germination.

The approximate seeding rate for carrots is 2 to 4 kg per hectare (raw seed) and 3 to 5 kg per hectare for parsnips (raw seed). Seed in single rows or bands 10 cm wide, 60 to 70 cm apart or in beds of 3 or more rows 15 to 45 cm apart depending on the minimum required by the plants or the planting and/or harvesting equipment. Space carrots at 40 to 66 per meter of row and parsnips 25 to 35 per meter of row depending on the soil type and row width. Higher plant populations require more water and fertilizer and reduce average root size. The closer plant spacings should be used on peat soils.

Crop Management

Cultivation should be kept to a minimum to reduce root pruning.

Hilling at last cultivation will reduce green shoulders on susceptible varieties.

Nutrition

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Carrots in research trials on mineral soils in the Atlantic area have shown little response to application of N, P and/or K fertilizers. The use of fresh manures in the spring has not led to any problems with forking of roots and has increased grower yields.

Lime — Limestone should be applied to maintain the soil pH in the range 6.0 - 6.8. Parsnips are more sensitive to acid soils than are carrots. Gypsum may be used on coarse sands where calcium levels are low and the pH is quite high to increase soil calcium and sulfur levels.

Nitrogen — Small applications are usually made at the time of seeding and the crop is often sidedressed in late August or September if it appears the top growth is not sufficient for effective harvesting. Research results do not indicate a yield response to applied nitrogen. Individual recommendations must be made for those growing on organic soils. On parsnips excessive nitrogen may encourage foliar diseases.

Phosphorus — Apply phosphorus to maintain reasonable soil levels of this nutrient.

Potash — Crops may respond to potash if it is low. Maintenance levels of potash are usually applied by growers.

Micronutrients — *Magnesium* deficiency may occur where dolomitic limestone has not been used. Mg0 may be included in the fertilizer but it would be recommended to use dolomitic limestone. Apply some *boron* in the fertilizer (.2 to .3B) or apply 5.5 kg per hectare of Solubor to the soil before planting or as a foliar spray. *Copper* and *molybdenum* must be applied on peat soils. Apply copper sulphate (50 kg per hectare) and sodium or ammonium molybdate (5 kg per hectare).

Application Method — Generally nitrogen, phosphorus, potash, calcium and magnesium are broadcast and incorporated before planting since efficient banding equipment does not seem to be available. nitrogen is broadcast, if necessary. High rates of commercial fertilizers and manures applied preplant will damage germination. If high rates are felt to be necessary broadcast the phosphorus and part of the nitrogen and potash. Then sidedress the balance of the nitrogen and potash later in the growing season.

Pests and Pest Control

Weeds

Perennial weeds should be controlled prior to planting. Preemergence herbicides usually provide good weed control. Carrots can be severely injured by preemergence herbicides when heavy rainfall or a high water table coincides with carrot emergence. Postemergence treatments are also available for annual broadleaf weeds and grasses. However the stage of crop and weed growth is critical for good control with no crop injury.

Diseases

Leaf Spots and Blight (fungi)

Characteristics: *Cercospora* leaf spots are brown to gray and circular. *Alternaria* blotches are irregularly shaped brown to black and more prevalent on older foliage. Both are seed and soil borne, can be spread by wind, rain splash and farm implements but will only infect leaves when they are wet.

Control: Apply sprays at 7 to 10 day intervals starting the first week of July or if fields are checked regularly then when disease is first detected. Continue spraying until 3 weeks of harvest. Spray intervals can be increased if there is no rainfall and night temperatures are cool (minimum temperature below 15°). Follow a 2-3 year rotation and plow down carrot debris promptly following harvest. Storages and crates should be disinfected.

Gray Mold (Botrytis) and Sclerotinia White Mold (fungi)

Characteristics: Both fungi produce decays on stored carrots. The former has a gray, "fuzzy" appearance while the latter produces white cushions of mycelium which may contain hard black pea-sized fungal structures.

Control: Plant on a well-drained soil not recently used for beans, lettuce, peas, tomatoes, carrots or cabbage. Practice a 3 year rotation. Store carrots at 0°C with a relative humidity of 95 to 98%. Spray or dip washed or unwashed carrots with an appropriate fungicide prior to storage if carrots are not for export.

Carrots & Parsnips

Introduction

Carrot (*Daucus carota*) and parsnips (*Pastinaca sativa*) belong to the Umbelliferae (the carrot family). This family includes other vegetables such as celery, celeriac, parsley and several herbs. Both carrots and parsnips originated in the Mediterranean area and were in use over 2000 years ago. Carrots (Queen Anne's Lace) in Southeast Europe and Afghanistan — parsnips in central and southern Europe. Both are botanically biennial plants which were first used as medicines and then became popular as food crops — parsnips in the 16th century in Europe and the orange carrot in the 17th century in Holland. The edible part of these plants is an enlarged taproot.

Carrots are grown in the tropics where high elevations give cool night temperatures and in temperate regions of the world. Optimum growing temperatures for these crops are 15-20°C with a minimum of 5°C and a maximum of 24°C. The minimum temperature for germination is 2°C with an optimum range of 10°to 25°C. The optimum germination temperature for parsnips is 18°C and carrots is 27°C. The maximum temperature for germination is 30°C and 35°C respectively. These crops therefore favor cool season conditions. Low and high temperatures reduce seed germination. Both carrot & parsnips foliage is affected by light frosts (−1.5°C) but is not harmful to the roots. Adequate moisture is necessary for good yields and quality. Parsnips usually overwinter well on sandy well drained soils. When seedlings with roots 6 mm in diameter or larger are subjected to cold temperatures (below 10°C) for a period of time flower initiation takes place. For early seeded carrots of susceptible varieties, bolting may occur in the Atlantic area.

A deep well aerated soil, free from stones and well supplied with moisture is required for the development of long smooth roots. Well drained sandy loam and organic soils are preferred. Seed germinates over a 2 week period or is restricted if a crust forms on the soil surface. The earliest seeds to germinate produce the largest roots. The seed bed also has to be prepared free of clods since hilling of cylindrical varieties is required late in the season to prevent greening or "sunburn". Planting on hills also increases the length of carrots. Soil compaction affects root growth and length. In compacted soil the taproot is conical in shape and the root is usually heavily furled.

Carrot harvest begins with the bunched crop in mid July. Roots for packaging are harvested starting in early to mid August. By September 1st carrot harvest is intensifying. By mid September harvesting of the storage and processing crops are in full swing. Carrots harvested from mid September to November yield a gross weight of 30,000 to 80,000 kg per hectare. Marketable yields average 20,000 kg per hectare (fresh or processed).

Parsnip harvest usually begins in mid September for fresh market and storage although some hand harvest may be done for roadside market sales in early September. Parsnip yields are 20,000 to 30,000 kg per hectare.

Carrot production in the Atlantic area is important due to a large fresh market and processing industry. It is a crop with a high per capita consumption and there appears to be some potential for increased consumption of both fresh and processed products. Parsnip consumption in this area is traditionally high and it is not anticipated there will be much increase in this market. Carrot growers usually produce some parsnips to make up truckloads and hopefully increase overall profits.

There may be some markets for speciality crops such as baby carrots (fresh and processing), large carrots for HRI trade, and parsnips for processing.

Nutrient Content of Carrots: One of our best sources of Vitamin A. One medium raw carrot supplies our daily requirement of this nutrient. It also contains other vitamins and minerals including potassium. 1 raw carrot contains 20 kilocalories. 250 mL (1 cup) cooked carrots has 47 kilocalories.

Nutrient Content of Parsnips: Good source of calcium, potassium and folate. Contains small amounts of other nutrients including Vitamin A and C. A 250 mL (1 cup) serving of cooked parsnips contains 186 kilocalories.

Crop *Establishment:*

Seed Treatment — Usually pelleted seed is purchased for use in precision seeders. High quality seed is essential for good germination and seedling vigor.

Seeding/Planting — Sow as early as the soil can be prepared. This is usually late April or early May. Soil moisture levels then are usually higher, there are fewer problems with crusting and generally better

stands result from early seedling. Late seeded crops may burn off if they emerge during hot dry weather.

The seeding depth should not exceed 0.6 to 1.2 cm. Deeper planting results in uneven or no germination.

The approximate seeding rate for carrots is 2 to 4 kg per hectare (raw seed) and 3 to 5 kg per hectare for parsnips (raw seed). Seed in single rows or bands 10 cm wide, 60 to 70 cm apart or in beds of 3 or more rows 15 to 45 cm apart depending on the minimum required by the plants or the planting and/or harvesting equipment. Space carrots at 40 to 66 per meter of row and parsnips 25 to 35 per meter of row depending on the soil type and row width. Higher plant populations require more water and fertilizer and reduce average root size. The closer plant spacings should be used on peat soils.

Crop Management

Cultivation should be kept to a minimum to reduce root pruning.

Hilling at last cultivation will reduce green shoulders on susceptible varieties.

Nutrition

ALL ADDITIONS OF LIME AND FERTILIZER OR MANURES SHOULD BE BASED ON RECOMMENDATIONS FROM A SOIL TEST. WHEN TEST RESULTS ARE NOT AVAILABLE THE GENERAL REQUIREMENTS FROM TABLES 1 - 4 OF THE SOIL AND WATER MANAGEMENT SECTION OF THIS GUIDE MAY BE FOLLOWED.

Carrots in research trials on mineral soils in the Atlantic area have shown little response to application of N, P and/or K fertilizers. The use of fresh manures in the spring has not led to any problems with forking of roots and has increased grower yields.

Lime — Limestone should be applied to maintain the soil pH in the range 6.0 - 6.8. Parsnips are more sensitive to acid soils than are carrots. Gypsum may be used on coarse sands where calcium levels are low and the pH is quite high to increase soil calcium and sulfur levels.

Nitrogen — Small applications are usually made at the time of seeding and the crop is often sidedressed in late August or September if it appears the top growth is not sufficient for effective harvesting. Research results do not indicate a yield response to applied nitrogen. Individual recommendations must be made for those growing on organic soils. On parsnips excessive nitrogen may encourage foliar diseases.

Phosphorus — Apply phosphorus to maintain reasonable soil levels of this nutrient.

Potash — Crops may respond to potash if it is low. Maintenance levels of potash are usually applied by growers.

Micronutrients — *Magnesium* deficiency may occur where dolomitic limestone has not been used. MgO may be included in the fertilizer but it would be recommended to use dolomitic limestone. Apply some *boron* in the fertilizer (.2 to .3B) or apply 5.5 kg per hectare of Solubor to the soil before planting or as a foliar spray. *Copper* and *molybdenum* must be applied on peat soils. Apply copper sulphate (50 kg per hectare) and sodium or ammonium molybdate (5 kg per hectare).

Application Method — Generally nitrogen, phosphorus, potash, calcium and magnesium are broadcast and incorporated before planting since efficient banding equipment does not seem to be available. nitrogen is broadcast, if necessary. High rates of commercial fertilizers and manures applied preplant will damage germination. If high rates are felt to be necessary broadcast the phosphorus and part of the nitrogen and potash. Then sidedress the balance of the nitrogen and potash later in the growing season.

Pests and Pest Control

Weeds

Perennial weeds should be controlled prior to planting. Preemergence herbicides usually provide good weed control. Carrots can be severely injured by preemergence herbicides when heavy rainfall or a high water table coincides with carrot emergence. Postemergence treatments are also available for annual broadleaf weeds and grasses. However the stage of crop and weed growth is critical for good control with no crop injury.

Diseases

Leaf Spots and Blight (fungi)

Characteristics: *Cercospora* leaf spots are brown to gray and circular. *Alternaria* blotches are irregularly shaped brown to black and more prevalent on older foliage. Both are seed and soil borne, can be spread by wind, rain splash and farm implements but will only infect leaves when they are wet.

Control: Apply sprays at 7 to 10 day intervals starting the first week of July or if fields are checked regularly then when disease is first detected. Continue spraying until 3 weeks of harvest. Spray intervals can be increased if there is no rainfall and night temperatures are cool (minimum temperature below 15°). Follow a 2-3 year rotation and plow down carrot debris promptly following harvest. Storages and crates should be disinfected.

Gray Mold (Botrytis) and Sclerotinia White Mold (fungi)

Characteristics: Both fungi produce decays on stored carrots. The former has a gray, "fuzzy" appearance while the latter produces white cushions of mycelium which may contain hard black pea-sized fungal structures.

Control: Plant on a well-drained soil not recently used for beans, lettuce, peas, tomatoes, carrots or cabbage. Practice a 3 year rotation. Store carrots at 0°C with a relative humidity of 95 to 98%. Spray or dip washed or unwashed carrots with an appropriate fungicide prior to storage if carrots are not for export.

Root Knot (nematodes)

Characteristics: Carrots may have forked roots, irregular round galls and spindle-shaped enlargements on tap and side roots.
Control: Where root-knot nematodes are a problem, soil can be fumigated. Rotation or summer fallowing will reduce nematode numbers considerably.

Aster Yellows (mycoplasma)

Characteristics: Yellowish, dwarfed leaves, usually forming a tight rosette. Older leaves may develop reddish margins. The root at the crown may bulge up into a cone and many hairlike roots develop on the root. The mycoplasma overwinters in many perennial weeds and is spread by leafhoppers.
Control: Destroy weeds in fields, headlands, ditch banks, fencerows, etc. Avoid planting near susceptible crops. See leafhopper control.

Parsnip Diseases

(Itersonilia) Canker or Blight (fungus)

Characteristics: Leaf spots appear as small silvery areas which later enlarge to brown irregular shapes with indistinct dark borders. Cankers are most prevalent near the shoulder of the root; they begin where rootlets are attached to the taproot. Affected areas are first brown to reddish-brown, later becoming black as cankers develop and as affected areas become depressed. The fungus overwinters in diseased plant residue. Disease is worst in cool wet conditions.
Control: Apply five sprays at 7 to 10 day intervals beginning the first of August. In addition to spraying, beneficial results are obtained by gradually hilling the rows. Every 10 to 14 days add a small amount of soil to the ridge until the rows are well covered.

Insects

Carrot Rust Fly

Characteristics: Damage is caused in feeding by yellowish-white, legless maggots which are 8 mm long when fully grown. Attacks result in stunting of carrot and parsnip plants. Roots may be reduced in size or distorted, scarred and riddled with rust-red burrows of the larvae. Seedlings may be killed if the growing tips are severely injured. Adult flies appear twice, in early summer and late August, and lay eggs, which hatch 6-12 days later into larvae. Adults may shelter at field margins increasing risk of damage in these areas.
Control: Where a known population exists chemical controls should be applied at planting. Planting may also be delayed until after mid-June to avoid the first generation of flies. Carrots may be harvested early (in late August or early September) before the maggot leaves the hair roots and enters the main tap root.

Aster (Six-spotted) Leafhopper

Characteristics: The leafhoppers can carry aster yellows from plant to plant as it feeds. They are small (4 mm long), slender, wedge-shaped insects. They are greenish-yellow in colour. Once a leafhopper feeds on an infected plant, it can spread it to all the other plants it feeds on. They feed on many other crops such as potatoes, tomatoes, celery, spinach, lettuce, onion and squash.
Control: If granular insecticide was used for rust fly control at planting time, leafhoppers will be controlled until mid-July. At this time it will be necessary to apply foliar insecticides. If granular insecticide was not used, foliar sprays are required beginning the first week of July and repeated at 10 day intervals until the end of August. Spray field boundaries also.

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Harvesting and Handling

To inhibit carrot sprouting, apply maleic hydrazide 4 to 6 weeks before harvest when the tops are in good condition. Follow manufacturer's directions.

Storage and Conditioning

Desirable storage conditions are a temperature of 0°C with a relative humidity of 95% to 98%. Carrots should keep 4 to 5 months under these conditions. Bunched carrots may be kept 10 days to 2 weeks at 0°C if the tips are not crowded. Do not store with apples or other fruits, as ethylene gas given off is one cause of bitter flavor in carrots. Good market quality of parsnips is the result of starch changing to sugar; this occurs after 2 to 3 weeks below 1°C in storage. It is not necessary to leave parsnips out over winter or to freeze them, although they are not injured by chilling. Because parsnips are susceptible to wilting, humidity must be kept high.

Maintaining sufficiently high humidity may be a problem, particularly in cold storage, with both carrots and parsnips. For information on "jacketed storage", contact your Provincial Department of Agriculture.

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Celery

Introduction

Celery is a member of the Umbelliferae (carrot family) *Apium graveolens* is an erect strong smelling biennial (botanically) 30-60 cm tall. It is native to the British Isles and is a widespread native of temperate Europe growing in damp places especially near the sea. Cultivation probably originated in the mediterranean area. Greeks and Romans used it only as a medicine 2000 years ago. In 1623 the use of celery as a food crop is recorded. Since then the crop has been improved by more fleshy leaf stalks to give the succulent vegetable we know today.

Celery production is best in a cool, humid and long growing season with an ample and uniform supply of moisture. Germination occurs at a minimum temperature of 5°C with an optimum range of 15°- 21°C, an optimum temperature of 21°C and a maximum temperature of 30°C. Optimum growth occurs at soil and air temperatures of 12°C to 16°C. Exposure to cold (2-4°C) for 10 - 15 hours will initiate a flowering process. Even temperatures from 5°C to 10°C for 10 days will promote seed stalk formation. Celery plants for transplants should be grown above 16°C. This crop will withstand light freezes in the fall but is damaged by several moderate freezes.

Well drained peat with a high water table is optimum for celery production. Satisfactory crops can be produced on fertile, medium textured mineral soils with high organic matter under irrigation. Most of the celery root system is with the top 15 cm of soil but some roots penetrate as deep as 2 feet. Clay soils are generally unsuitable.

Celery can be produced in tunnel houses for early or late markets (Early July to late August and from October into November respectively). Main crop celery can be produced from mid August to late October depending on the microclimate. Yields of 30,000 to 50,000 kg per hectare are possible where growing conditions are favourable.

In terms of markets only green cultivars are commercially acceptable unless there are speciality markets for yellow or blanched cultivars. Currently little celery is produced in the Atlantic area. It has become an important crop because of the growth in salad vegetables so consumption is on the increase. It is also a vegetable that has a reasonably high per capita consumption. There would seem to be opportunity to produce this crop for wholesale and retail markets. It has not been determined if there is any processing potential for this crop.

Nutrient Content: Contains fair amounts of several nutrients including Vitamin A, potassium and sodium. Very low in calories — 1 stalk contains 5 kilocalories.

Crop Establishment

Seed Treatment — Three year old seed should be used to ensure the absence of viable leaf blight disease on seeds. Otherwise it must be hot-water-treated.

Seeding/Planting — Growing transplants — sow seed 10 to 12 weeks before field planting — (usually in mid June). Approximately 150-200 grams of seed provide enough plants for 1 hectare (75,000 to 135,000 plants) when the standard field spacing is used (seedlings are pricked out at 4-5 weeks). Until the plants emerge a temperature of 21 to 24°C is suitable. Then 18 to 24°C is ample for steady growth. Night temperatures should not dip below 13°C to lessen the production of "bolters".

Plants for the early crop should not be set in the field until the danger of a prolonged cool period or actual freezing is over.

If the plants have become too tall and spindly before field setting they can be clipped back to a height of 12 to 15 cm. Clipped plants facilitate transplanting but well grown, untrimmed plants are preferable because they receive less check in growth.

Outdoor seedbeds may not be a feasible way to produce transplants in this area due to the short season.

Field Transplanting — The usual field spacing is 15 to 20 cm between plants in rows 60 - 100 cm apart or in paired rows 20 cm apart with 60 to 100 cms between pairs.

Crop Management

For succulent and tender stalks, high soil moisture is necessary. Water must be regularly supplied at frequent intervals and more moisture is needed in the last month before harvest as the most rapid growth occurs at this time. About 75 cm of water are required to grow the crop to maturity.

Cultivation or hand hoeing may be necessary depending on the weed problems. Plastic mulches may be used to control weeds in some situations.

Nutrition

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Celery is a heavy feeder and a poor forager so on all but the richest soils large quantities of nutrients should be applied.

Manure — where it is available its use is recommended. Up to 100 tonnes per hectare may be applied.

Lime — Lime should be applied to maintain the soil pH in the range 6.0 - 6.8 (preferably above 6.5). Lower pH levels are tolerated on peat soils.

Nitrogen — Celery has a high nitrogen requirement. Apply two-thirds of the nitrogen at planting time and the remainder sidedressed in 2 to 3 applications as required.

Phosphorus — This fertilizer is usually broadcasted preplant in moderate applications.

Potash — Sandy loam soils may be low in potash. On these soils incorporate preplant. Reduce the rate of potash if it is sidebanded.

Magnesium — Ratios of potassium to magnesium should be reduced by using dolomitic limestone. Deficiencies may also be corrected by spraying with magnesium sulphate at 10 day intervals (10 - 15 kg per hectare).

Calcium — "Black heart" a sign of calcium deficiency, may be avoided with use of calcium nitrate and/or calcium chloride applications. Spray directly into the heart of the plant 2.2 - 4 kg calcium (from calcium chloride) or 1.2 - 3.4 kg calcium (from calcium nitrate) per 1000 L of water. If celery is under moisture stress or humidities are high repeat once per week.

Sulfur — is suggested on sandy soils low in organic matter.

Micronutrients — *Boron* — "Stem cracking" is a sign of boron deficiency. It can be prevented by applying 0.2% Boron in the fertilizer and/or later in the growing season as a foliar spray (4 kg per hectare of Solubor in sufficient water for coverage along with a "spreader" when plants are about 15cm tall).

Salt (NaCl) — This is used in some growing areas to increase yields. This should be ploughed into the soil at least a month before transplanting.

Manganese — On soils with a pH of over 6.5 this nutrient may not be available to the plant. Spray with manganese sulphate at 9 kg per hectare.

Application Method — broadcast before planting and incorporate part of the nitrogen, potash and salt. Band if possible phosphorus and small amounts of nitrogen and potash.

Pests and Pest Control

Weeds

Perennial weeds should be controlled prior to planting. Herbicidal oil can be used to control annual broadleaf weeds in the seedbed. Herbicides can be applied 8 to 10 days after transplanting to control germinating annual weeds.

Diseases

Damping-Off (fungi)

Characteristics: Damping-off causes an early collapse of young seedlings.

Control: Grow seedlings in sterlized soil. Treat seed with fungicide before seeding, or drench immediately after seeding. Do not overwater or crowd seedlings.

Leaf Blight (fungi)

Characteristics: Leaf blights are commonly caused by either one of two fungi, *Cercospora* or *Septoria*. Both overwinter on and in seed and in debris from diseased plants. These diseases are spread by wind, rain splash and movement of workers or implements in the field. *Cercospora* can be recognized first by yellow spots on both sides of the leaves which enlarge rapidly and become ash gray. *Septoria* shows as a yellowish speckling, later turning yellowish grey. Very small, black specks (fungus fruiting bodies) are associated with, and usually within, the spots. Each disease can affect petioles as well as leaves.

Control: The fungi are seed and soil borne. Every effort should be made to produce disease-free seedlings (grown in sterilized soil using a 3-year old seed or hot-water-treated seed). Where leaf blights have been a problem in the past, spray the seedlings with field sprays at half strength. Begin spraying when seedlings are 5 cm high and continue weekly throughout the season.

Pink Rot (fungi)

Characteristics: Plants wilt and collapse in the field due to watery, pinkish rot of crown and petioles. Under wet conditions decayed area may be covered with a white mold having hard black pea-sized fungal structures.

Control: Following other crops in rotation such as carrots, beans, lettuce and cabbage increases risk of disease. Always plow under field debris immediately after harvest.

Aster Yellows (mycoplasma)

Plants are light yellow with elongated, twisted leaves. Later the plants become yellow and dwarfed and the petioles become brittle and frequently crack. Spread by leaf hoppers.

Control: Control weeds that harbour the organism and control leaf hoppers.

Tarnished Plant Bug

Characteristics: A serious insect pest, often causing complete crop loss. Adults are small (6 mm) oval insects that vary from straw green to dark brown with yellowish, reddish-brown and black mottling. Adults are very active, quickly flying away when disturbed. They overwinter under bark or leaf-litter, emerging early in the spring and feeding on weeds and fruit buds. After mating, eggs are laid on stems and petioles. Nymphs (yellowish-green, 1 mm long) emerge after 10 days, undergoing two molts to become adults within 3 - 4 weeks. Adults and nymphs are equally damaging, their feeding distorting stalks, often causing breakdown resembling black heart.
Control: Controls for aster (six spotted) leafhopper will be effective against this insect also. Burying of weeds and trash near crop areas will also help to reduce pest numbers.

Aster (Six-spotted) Leafhopper

Characteristics: The leafhoppers are small (4 mm long), slender, wedge-shaped insects; they are greenish-yellow in color. They can occur in large numbers throughout the season. Leafhoppers transmit aster yellows disease.
Control: Apply 3 to 4 sprays at 10-day intervals beginning early July. Also spray weeds in headlands and control leafhoppers on adjacent carrots and lettuce.

Aphids

Characteristics: Aphids are small, soft-bodied, slow-moving insects. They are often found in large colonies on the undersurface of leaves. A colony consists of winged and wingless adults and various sizes of nymphs. Aphids may be black, yellow or pink, but mostly are various shades of green. Aphids feed by sucking plant sap. Saliva injected while feeding may carry plant viruses or may be toxic to the host plant. Feeding by large numbers discolors foliage and curls leaves. The plants may be covered with a sticky substance, honey dew, which is excreted by the aphids.
Control: Apply recommended pesticides when aphids are numerous.

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Harvesting and Handling

Celery may be harvested as soon as it reaches marketable size. Early celery can be harvested before it is full grown if high market price for early cropping justifies it. Cut the stalks below ground level with a sharp blade. Trim off outer leaves and pack in crates.

Storage and Conditioning

Celery can be stored 1 to 2 months at a temperature of 0 to 1°C and 98 to 100% relative humidity. The freezing point is −0.2°C. Celery is highly perishable, and when warm and wet it decays rapidly. Precooling is essential and is usually accomplished by hydrocooling or vacuum. Packaging in well ventilated plastic is frequently used to protect it from wilting.

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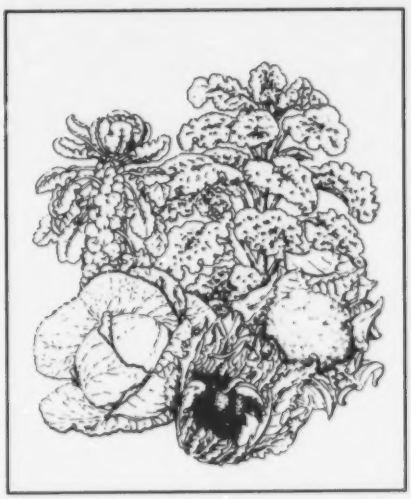
Cole Crops



Introduction

Cole crops are members of the cruciferae (mustard family)

Cole Crops include: cabbage — *Brassica oleracea* var *Capitata*

Cauliflower — *Brassica oleracea* var *Botrytis*

Broccoli — *Brassica oleracea* var *Italica*

Brussel Sprouts — *Brassica oleracea* var *Gemmifera*

Kale — *Brassica oleracea* var *Acephala*

Kohlrabi — *Brassica oleracea* var *Gongylodes*

Cole crops originated from the word caulis (latin) meaning stem or stalk of a plant. Today cole crops, means the stem brassicas.

It is assumed that the cabbage and kales originated in western Europe and that cauliflower and broccoli came from the Mediterranean region. Cabbages and kales were the first to be domesticated. Prior to cultivation and use as food, they were used mainly for medicinal purposes. The first description of cauliflower appeared in 1544. Brussels sprouts, named after the city in Belgium, did not occur until the beginning of the 19th century. The sprouting broccoli of today originated in the Mediterranean area. Cole crops are biennials but are generally grown as annuals. At the seedling stage, these different crops are hard to distinguish. Except for certain strains of cabbage, broccoli and tropical type cauliflower a cold period is necessary for flowering.

The brassica family are well adapted to cool season production. These plants are quite cold resistant. Young hardened cabbage plants can withstand −10 to −12°C for a short time, older plants are less hardy. The growth rate of cabbage is at a minimum at 0°C and is optimal at 15°C to 20°C. Above 25°C growth stops. Cole crops require a regular water supply of 85 to 100 mm per season. Shortage of water is detrimental for head development. The minimum temperature for seed germination is 5°C with an optimum germination temperature of 27°C, an optimum range of 7 to 27°C and a maximum germination temperature of 37°C. Cauliflower and broccoli will not stand temperatures as high or low as cabbage. High temperatures delay maturity and increase vegetative growth (number of leaves) and cool temperatures hasten maturity and may induce "bolting". Young hardened plants can withstand −5 to −10°C. An optimum growth rate occurs at 15°C to 22°C and growth stops above 30°C. Fluctuating temperatures may induce some cauliflower cultivars which are heading to revert back to the vegetative phase which results in poor quality curds (bract formation). Kale is the hardiest of all cole crops. It can withstand temperatures of −10 to −15°C. Kohlrabi is sensitive to cold temperatures. A week at 10°C will cause the plant to bolt.

Cole crops require soils that can provide a continuous water throughout the season. Well drained, sandy loam soils are suited to early varieties, loamy and clay loam soils are suited to late ones. Late cultivars are somewhat tolerant of poor drainage. Well drained soils can be rotated closely since clubroot is easier to control.

Early cabbage is usually transplanted in late April or early May and maturity is usually in early July. Cabbage can then be in continuous supply until March or April of the following year. Some cabbage may be stored until June in the best refrigerated storage. Yields are low for early cabbage and highest for kraut and cole slaw cabbage. A marketable yield would range from 20,000 to 40,000 kg per hectare.

With tunnel house production early cauliflower cultivars may produce in late June. Early field production does not start until early July. Cauliflower is then available with some refrigerated storage until early December. Yields vary with the field and growing conditions from 800 to 2000 dozen per hectare.

Broccoli production and earliness depends on the degree of bolting but with the use of tunnel house this first crop could be harvested in early June. Field production would begin in early July and continue until the end of October. With a short storage period the crop marketings are usually completed by mid November. Due to head rot and bolting yields are variable from 750 to 1500 dozen per hectare.

Brussel Sprouts are grown mainly for processing markets to be harvested in late September, October and early November. On the fresh market they may be sold early in September and the marketing period extended by refrigerated storage until early December. Yields for both markets are 7000 to 9000 kg per hectare.

Kale and kohlrabi are grown only in small quantities for specialty markets.

The cole crops are extremely important to vegetable production in the Atlantic area. They are important fresh and processing crops which are increas-

ing in consumption and which are well suited to the climate of this area. They are crops which do not require high amounts of labor and which can be further mechanized. There may also be wholesale speciality markets that could be developed for certain crops or cultivars in the cole crop family e.g. kohlrabi, red cabbage, savoy cabbage, mini cauliflower, fresh broccoli spears, cauliflower florets and mini cabbage.

Nutrient Content:

Broccoli: Very good source of Vitamins A and C; rich in potassium, calcium and phosphorus, folate; contains some iron. 250 mL (1 cup) cooked broccoli contains about 45 kilocalories.

Brussels Sprouts: Very good source of Vitamins A and C; rich in potassium and folate. Contains other nutrients in small amounts. 250 mL (1 cup) serving contains 58 kilocalories.

Cauliflower: Good source of Vitamin C, folate and potassium. Supplies small amounts of several minerals and vitamins to the diet. 250 mL (1 cup) cauliflower supplies 26 kilocalories.

Cabbage: Excellent source of Vitamin C. In addition to containing some B vitamins, cabbage supplies some potassium and calcium to the diet. 250 mL (1 cup) raw cabbage contains 21 kilocalories; cooked 58 kilocalories.

Crop Establishment

Seed Treatment — Cole crop seed can be sized and/or pelleted for precision seeding of module trays or direct seeding into the field. With the cost of hybrid seed almost every seed must produce a marketable plant. Advances in quality seed both in terms of vigor and germination percentage has led not only to an increase in module transplant use but also a reconsideration of direct seeding.

Seeding/Planting — For early markets plants must be raised in greenhouses. About 5 to 6 weeks are required to produce transplants. Young plants with 4 or 5 leaves are generally superior to older ones. The temperature should be maintained between 13 and 24°C. Slight hardening is beneficial but severe hardening may stunt growth. Large or old plants of cauliflower and broccoli and those grown at low temperatures (10 to 15°C) are likely to button (bolt) if exposed to a period of cool weather after field setting. Plants may be grown in module trays, in peat blocks or in paper cells. Normally 300 to 350 grams of seed will produce enough plants for 1 hectare.

Plants for late crops may be planted in module trays, field seed beds, greenhouse seedbed, or direct seeded. (Space seedbed rows 25 to 30 cm apart and seed 20 seeds per 25 cm of row with a scatter shoe seeder.) When direct seeding 550 to 850 grams per hectare are required since seed is generally planted at twice the final spacing. Direct seed two to three weeks earlier than transplanting for the same harvest date. Seed .6 to 1.2 cm deep. Most cole crops should not be direct seeded after mid to late June.

Planting Spacing	Distance between Rows (cm)	Plants (cm)
Cabbage, early	60-75	30-40
Cabbage, late	75-90	30-70
Cauliflower	60-90	35-50
Broccoli	60-90	30-40
Brussels Sprouts	75-90	30-45

The newer compact hybrids may be grown at closer spacings than the older traditional cultivars. With Brussels sprouts grown for a once over harvesting and especially where smaller sprouts are required for freezing, uniformity of the sprouts up the stem can be improved by growing the plants at a closer spacing, eg. 60 × 60 cm. For broccoli crops to be harvested during the hot humid weather of August, plant spacings should be increased to the wider end of the range recommended to help reduce head rot. For bed culture of broccoli, cauliflower and cabbage rows may be spaced closer together and plants spaced further apart. This spacing depends on the crop, the cultivar, the fertility program, the size of the crop desired for market and the desired maturity date.

Crop Management

Cabbage splitting — It is mainly a problem with early cabbage. A problem can develop with moisture stress followed by heavy rain. The rapid growth rate associated with rain, high temperatures and high fertility cause the splitting. Proper irrigation may help prevent splitting and there are significant differences between varieties in their susceptibility to this problem. Splitting may also be partially avoided by deep cultivation to break some of the plant roots.

Cauliflower and Broccoli buttoning — Buttoning is the premature formation of a head and because the head forms early in the plant's life, the leaves are not large enough to nourish the curd to a marketable size. Buttoning usually occurs shortly after planting in the field, when normal plants of the same age are growing vegetatively. Losses are usually most severe in the early planted crop during cold, wet seasons, when vegetative growth is checked by: (1) hardening too much of greenhouse plants (2) too little hardening of greenhouse plants (3) low soil nitrogen (4) low soil moisture (5) continued cold weather (4 to 10°C for 10 days or more) (6) Other — disease, insects, micronutrient deficiency, etc. Some cultivars particularly early ones, are more susceptible to buttoning than others.

Hollow stem in broccoli and cauliflower — This condition starts with gaps that develop in the tissues. These gradually enlarge to create a hollow stem. Ordinarily, there is no discoloration of the surface of these openings at harvest but both discoloration and tissue breakdown may develop soon after harvest. Both plant spacing and the rate of nitrogen affect the incidence of hollow stem. As the plant spacing increases hollow stem increases. As the rate of nitrogen

increases then the rate of hollow stem increases. The incidence of hollow stem can be greatly reduced by increasing the plant population.

Cauliflower blanching — The market demands cauliflower which is pure white or pale cream in color. Heads exposed to sunlight develop a yellow and/or red pigment. The usual method to exclude light is to tie the outer leaves when the curd is 8 cm in diameter. Leaves may also be broken over the curd to prevent yellowing. In hot weather blanching may take 3 to 4 days, but in cool weather, 8 to 12 days or more may be required. Some cultivars give better natural curd protection by having inner wrapper leaves, (without tieing) especially those cultivars which have been bred in Europe. Cauliflower fields scheduled to mature in cool weather (September and October) that are well supplied with water and with "self-blanching" cultivars may not need tieing.

Irrigation — The availability of water can be critical to successful production. Steady even growth of these crops are necessary for high quality and yields. Irrigation may also be used to cool plants during periods of high temperature. Fertilizer could also be applied through an irrigation system.

Nutrition

ALL ADDITIONS OF LIME AND FERTILIZER OR MANURES SHOULD BE BASED ON RECOMMENDATIONS FROM A SOIL TEST. WHEN TEST RESULTS ARE NOT AVAILABLE THE GENERAL REQUIREMENTS FROM TABLES 1 - 4 OF THE SOIL AND WATER MANAGEMENT SECTION OF THIS GUIDE MAY BE FOLLOWED.

Cole crops are high fertility crops.

Manure — Half or more of the fertilizer can be replaced by 25 to 35 tonne per hectare. Do not use manure from animals that have been fed turnips or rutabagas. Excessive use of manure may contribute to tip burn, hollow stem, internal browning and other problems.

Lime — Lime should be applied to maintain the soil pH in the range 5.8 to 6.5.

Nitrogen — Adequate nitrogen produces a dark green color in cole crops leaves. Nitrogen deficient plant leaves are light green, eventually turn yellow and may be shed. There is a wide variation in the needs between cole crops and different cultivars of these crops. This is not generally recognized in soil test analysis sheets received from your soil lab. For early cabbage and broccoli the nitrogen is usually totally broadcast preplant and incorporated into the soil. For cauliflower and late cabbage up to 3 sidedressings of nitrogen may be made. Foliar sprays of urea may also be applied.

Phosphorus — A shortage of phosphorus stunts plants growth. Starter fertilizers high in phosphorus are recommended. Generally all the phosphorus is broadcast or all banded depending on the available transplanting equipment. Lower rates of phosphorus are required at high phosphorus levels but some should always be applied initially for a readily available source of phosphorus (50 kg per hectare P_2O_5).

Potassium — Potash usually is applied but cole crops are not responsive to potash when compared to nitrogen. On soils high in potassium no additional potash may be needed. Excessive potash may lead to increased tip burn (internal and/or external). Potash inhibits the uptake of calcium from the soil and this is probably what causes the increased tip burn. When potash is applied it is usually broadcast and preplant incorporated into the soil.

Magnesium — deficiency is fairly common especially on light acid soils where dolomitic limestone has not been applied. To correct this problem apply dolomitic limestone, add magnesium to the fertilizer and/or spray the foliage with epsom salts (magnesium sulfate).

Sulfur — on sandy soils low in organic matter that have been intensively cropped, soil sulfate levels may be low. Application of gypsum should be considered on these soils. Cole crops have the highest need of any crop for sulfur. Cauliflower have been showing signs of deficiency in many fields.

Micronutrients *Boron* — Deficiency may cause hollow stem and/or stem discoloration as well as browning of cauliflower curds. On soils known to be deficient in boron apply a boronated fertilizer (.2 to .3B to give 1.0 to 2.5 kg per hectare of boron) and foliar sprays of soluable boron. On high pH soils (over 6) use only foliar sprays of boron. (Solubor at 3.3 kg per hectare).

Molybdenum — Deficiency causes whiptail in cauliflower, broccoli and Brussel Sprouts. Molybdenum may be supplied as a seed treatment, as a foliar spray to transplants before field setting, in the transplant water or as a foliar spray. Apply 30 to 45 g of Sodium Molybdate per 100 L of transplant water or 280 g of Sodium molybdate as a spray in 1100 L of water per hectare. (Sodium molybdate is approximately 40% molybdenum). Excessive molybdenum is toxic to plants and animals — use with care. It will carryover in the soil.

Manganese — Deficiencies may occur on sandy, overlimed soils. Foliar sprays of manganese sulfate may be necessary to correct a deficiency.

Application Method — (1) Usually N, P & K are broadcast before planting and incorporated into the soil (2) N and P may be banded and the K harrowed into the soil before planting. (10 cm below and 10 cm to the side of the row (3) Where high rates of fertilizer are used half may be banded and half may be broadcast.

Sidedressings of nitrogen up to 112 kg of actual N may be applied through the growing season. Foliar sprays of urea may also be used (10 kg of urea per hectare).

Pests and Pest Control

Weeds

Perennial weeds should be controlled prior to planting. Herbicides recommended for use on cole crops will not provide complete control of weeds, therefore it is important to grow cole crops on soil

where the weed seed population is low. The weed seed reservoir in the soil can be reduced by crop rotation, summer fallow and stale seedbed technique. Care must be taken to avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur.

Diseases

Clubroot (fungus)

Characteristics: Clubroot is a soil borne disease which affects turnips and rutabagas, as well as cabbage, broccoli, Brussels sprouts, cauliflower and radish. The signs of the disease vary from swellings on roots of cabbage to severe malformation of the rutabaga root, accompanied in many cases by wilting, and frequently death of the plant. Throughout the Atlantic Provinces, it is a major problem where poor management practices are followed.

The fungus (*Plasmodiophora brassicae Wor.*) causing this disease is usually present in areas where rutabagas and cole crops have been grown for many years. Once land becomes infested, it will remain so for at least 7 years. Any producer intending to grow cruciferous plants must appreciate this fact. Infected plants are stunted and usually take on a bluish tinge at first, later turning yellow. (Root maggot infested plants may also show the same signs). Wilting is most common on warm sunny days; plants may show little wilting early in the morning or late at night. Small-to-large spindle-like or slug-shaped swellings develop on the roots of cabbage and other cole crops, large out-growths and misshapen roots occur on turnip and rutabagas.

The clubroot fungus enters the plant through the many fine hairs on the roots. The extent of the disease is affected by many factors. Moist, cool soils usually produce more diseased plants than dry, warm soil. The disease also thrives best in acid soils; that is, when the pH is below 7.

When clubbed plants rot and break down in the fall, the fungus spores are released into the soil, where they may live for many years, ready to infect any rutabaga or cole crop subsequently planted. Since the fungus spores are in the soil, movement of the soil by any means (boots, tools, wheels or wind and water, etc.) also spreads the disease.

Control: 1) One of the most important controls is to ISOLATE (if possible) or avoid use of infested fields for crucifer crops for about 7 years. The disease affects only the crucifer crops so any other crop may be planted as long as cruciferous weeds are not present.

2) Cattle fed infected plant material can pass the fungus spores in manure. Therefore, DO NOT APPLY CLUBROOT INFESTED MANURE on land to be used to grow crucifers. Put manure back on the field that contained the infected roots to prevent spreading disease to other fields or spread on permanent pasture land that will not be used for any susceptible crop and where run-off will not carry the disease to clean fields.

3) Practice a ROTATION. Do not grow a susceptible crop within a 5-7 year period to avoid infestation.

4) ALL EQUIPMENT used on infested land must be washed down and preferably steam cleaned or disinfected to prevent carrying the disease to clean fields. Live steam delivered at 690 kPa pressure for 5 minutes is the best method to disinfect equipment. Kem Germ at 30 g/L, or Javel products (Javex, Mix-O) at 1 part in 3 parts water, or Cresanol at 4 parts in 10 parts water are effective disinfecting agents.

5) Every effort to CONTROL SUSCEPTIBLE WEEDS should be made. Weeds of the mustard family will maintain or increase the level of infestation of clubroot in a field. Examples of susceptible weeds that occur in the Atlantic area are as follows: wild radish, wild mustard, field penny cress (stinkweed), pepper grass, shepherd's purse, false flax, hare's ear mustard, worm seed mustard and yellow rocket.

6) As clubroot seems to thrive best in moist, acid soils it is advisable to APPLY LIME to raise the pH of the soil to as near pH 7 as possible. Wet, poorly drained land should be avoided.

7) Use CLUBROOT-FREE TRANSPLANTS — The only way to ensure clean transplants is to use sterile soil. Clean boxes and equipment with steam. In the early stages of infection, plants may not show any signs of disease, so it is essential to purchase plants from a reliable source or to follow the procedures for producing healthy plants. Make sure you have enough clean plants for the area to be planted. Diseased plants beside healthy ones will result in all plants becoming infected. When growing transplants in the field, it is important to select a well drained area where it is known that clubroot has never occurred. Certain fumigants will control the clubroot organism.

Alternaria Leaf Spot (fungus)

Characteristics: Small to large black spots appear on leaves. It may be involved in discoloration and decay of cabbage heads, Brussels sprouts and cauliflower curds under very wet conditions. The disease organism is seed and soil borne. The first symptom of the disease is the appearance of small greyish-brown to black specks about 1-2 mm in diameter. These may appear at any time during the life of the crop. They usually are most conspicuous on the outer, older leaves. The spots enlarge in storage to sunken and black areas. *Alternaria* is a secondary fungus; it usually invades the plant after it has been injured by other pests.

Control: Use hot-water-treated seed. Practice long rotations between susceptible crops (turnips, cabbage, rape, other crucifers). Apply fungicides at first sign of disease at 7-10 day intervals. Cabbage intended for long-term storage should be treated 3-4 times ending 7 days prior to harvest. Keep storage temperature at 0°C and relative humidity at 92 to 95%. Periodic venting with outside cool air removes excess moisture from cabbage surface and reduces losses from decay in common refrigerated storages.

Downy Mildew (fungus)

Characteristics: Shows as a white, fuzzy fungus in patches on underside of leaves, stems and heads. It may cause browning and black streaking in stems and black spotting on heads of broccoli and cauliflower.

Control: Rotate land for at least 2 years. Avoid thick seedings, over-watering and the application of water after 3 p.m. In the seedbed, spray seedlings at germination and repeat twice until transplanted with an appropriate fungicide. In the field apply fungicides on a regular basis as required.

Blackleg (fungus) and Black Rot (bacterium)

Characteristics: Early signs of blackleg appear as small spots on leaves of young plants. On stems the spots are more linear and often surrounded by purplish borders. Stem lesions at the soil line usually extend to the root system causing dark cankers. The fibrous root system may be destroyed although new roots sent out above the lesion may keep the plant alive. Many plants wilt abruptly and die.

Black rot lesions first appear at margins of leaves. The tissue turns yellow and the lesion progresses toward the center of the leaf, usually in a V-shaped area with the base of the V toward the midrib. The veins become dark and discoloration frequently extends to the main stem and proceeds upward and downward.

Control: These organisms are seed borne and are capable of surviving in the soil for long periods without another cole crop (blackleg 3 years, black rot 1 year). Use only hot-water-treated seed and seed treated with antibiotic. Practice a 4-year rotation. Destroy cruciferous weeds as they may harbour the black rot organism.

Insects

Cabbage Root Maggot

Characteristics: The adult is a two-winged, ash-grey fly with black stripes on the mid-section. It is half the size of a housefly, but has longer legs. Larvae are white, legless maggots. The pupae are 6 mm long, oval, hard shelled and dark brown. There are two to three generations a year. Pupae overwinter in the soil near the roots of the host plant. Adult flies emerge in the spring and crawl to the surface. They fly close to the ground near host plants and lay elliptical white eggs on the stems or in nearby crevices in the soil. Eggs hatch in three to seven days. Maggots enter the roots and feed by rasping the plant tissue with a pair of hook-like mouthparts. They mature in three to four weeks and pupate. Flies emerge in two to three weeks. Larvae (maggots) feed by tunnelling in the roots. Young plants may be stunted or killed. Feeding damage by the cabbage maggot causes roots to be misshapen and allows the entry of decay organisms and other species of maggots.

Control: Apply insecticides as listed in Publication 1400A.

Cabbage Worm: *Imported Cabbage Worm, Cabbage Looper, Diamond-Back Moth Caterpillar, Purple-Backed Cabbage Worm*

Characteristics: Generally identified as green caterpillars, either large and velvety-green or small and active. These larvae eat holes in leaves and heads. Heavy infestations will virtually destroy the crop.

The adult of the Imported Cabbage Worm is a white butterfly, easily seen going from plant to plant laying eggs during the summer. The eggs become velvety-green larvae with one thin yellow stripe down the center of its back. The cabbage worm larvae does not loop when it walks. They are generally the most prevalent of the cabbage worms.

The cabbage looper gets its name from the way it loops up as it walks. It is a smooth green larvae with pale yellow stripes along the back and sides. They are heavy feeders.

The Diamond-Back Moth is much smaller than the previous insects. Three to six generations of 1.1 cm green larvae may develop each year. The larvae squirm actively when disturbed and produce many small holes on the host plant. This pest can bore into the heads of brussel sprouts and cabbage.

The Purple-Backed Cabbage Worm is not as commonly seen as the others but will cause serious damage in high numbers. The larvae are purple on the back and pale yellow along the sides. There are two generations per year.

Control: Check plants frequently and treat when damage is first observed and repeat at 7-10 day intervals. Include a spreader-sticker with all insecticide sprays and use enough water to wet the plants thoroughly. There are parasites that can also help keep a population in check.

Aphids

Characteristics: Aphids are small, soft-bodied, slow-moving insects. They are often found in large colonies on the undersurface of leaves. A colony consists of winged and wingless adults and various sizes of nymphs. Aphids may be black, yellow or pink, but mostly are various shades of green. Aphids feed by sucking plant sap. Feeding by large numbers may slow plant growth. The plants may be covered by a sticky substance, honey dew, which is excreted by the aphids.

Control: Apply recommended pesticides when aphids are numerous.

Onion Thrips

Characteristics: The onion thrips are a pest on cabbage. They are slender, yellow-brown insects about 1 mm long. They feed by puncturing the leaves and sucking up the exuding sap. This causes the appearance of blisters on the leaves. Once thrips enter the protection of the head, they will breed profusely. The injury may occur up to 20 layers deep in the head. They overwinter on refuse, weeds, and legume forage crops. Populations increase quickly when the air temperature is over 21°C.

Control: Destroy refuse and control weeds. Heavy migrations of thrips can occur following the cutting of forage, particularly alfalfa or clover. It is critical to control them at early head formation (7.5 cm leaf ball).

Cutworms

Characteristics: Cutworms are greyish, fleshy larvae up to 5 cm long, which curl up when disturbed. Plants may be chewed off above or below ground level and may be damaged higher up by climbing cutworms. Most of the cutworm damage is to newly set plants in the field, but they are often found attacking seedlings in plant beds and greenhouses.

Control: Apply insecticides when early cutworm injury is detected.

Slugs

Characteristics: Slugs exist is various sizes up to 10 cm. They eat holes in the leaves and leave a trail of mucus, which makes plants unsightly. The control of slug populations has been a continuing problem in the cole crop industry.

Control: Slugs prefer areas which are cool, moist and high in organic matter. Sod crops, weedy fence lines and hedgerows fulfil these conditions. Since slugs can overwinter fairly easily, cultural practices aimed at controlling them should begin at least one year before the susceptible crop is put in. If at all possible, sod crops should not be followed by cole crops. A cultivated strip around the crop has been shown to reduce the number of slugs migrating from weedy field borders. If urea (4 kg/ha) is sprayed on this cultivated strip, slug movement may be further impeded. The salt irritates the pests, as they move over it. Repeated applications are necessary as rainfall washes it into the soil.

Non-parasitic Disorders

Cole crops show various non-parasitic disorders which cause tissues to die off. In some cases, these deviations have been shown to depend mainly on heritable characters; whereas, in other cases external factors had at least marked effect.

Internal Browning

Characteristics: In Brussels sprouts, the symptoms are a yellowing of the distal ends of the leaves within the sprout, generally on a line through the center region of the sprout and midway between its growing point and exterior surface. From a practical aspect, 'internal browning" is especially troublesome because it cannot, usually, be detected from external examination of the sprouts, yet quite a small number of affected sprouts may taint a large sample – especially when they are blanched for quick-freezing.

Factors which have contributed to internal browning have done so by bringing about a temporary localized calcium deficiency in the sprouts. Rapid growth, low soil moisture and high relative humidity which inhibits transpiration, are commonly implicated. The actual soil calcium levels have very little influence unless they are extremely low.

Control: Ensuring the soil moisture is close to field capacity can reduce the risk of internal browning. Excessive nitrogen fertilizer should be avoided. Foliar sprays of calcium nitrate may prevent the onset of internal browning if applied before the onset of adverse growing conditions.

SPECIFIC CHEMICAL CONTROLS FOR THE VARIOUS CROP PESTS DISCUSSED MAY BE FOUND IN THE SUPPLEMENT TO THIS GUIDE, A.P.A.S.C.C. PUBLICATION 1400A, "A GUIDE TO CULTIVAR SELECTION AND CHEMICAL PEST CONTROL FOR VEGETABLE CROPS."

Harvesting and Handling

Cabbage

Heads of cabbage can withstand some frost, although fairly large differences in frost hardiness occur between the varieties. Frozen tissues generally have a water soaked appearance, but if not damaged the tissues will look normal again after thawing. On the other hand, damaged tissues often show brown discolorations. The youngest leaves are particularly sensitive to frost, so that the center of the head may be damaged by frost and turn brown, while outwardly the head looks healthy. These disorders also occur in the buttons of Brussels sprouts.

Brussels sprouts

a) Topping: Topping checks stalk elongation and promotes the development of the individual sprouts.

The most advantageous time for topping (that which will produce uniform sprouts on the entire length of the stalk) has not been firmly established. Indications are for 'Jade Cross' that topping is best with initiation of sprouts on the seventh whorl on the stalk. This usually occurs in early September.

b) De-leafing: Harvesting commences when the sprouts have reached marketable size and firmness.

c) Stem-cutting: This can also be accomplished by hand or by a machine in combination with a conveyor system that loads the stalks directly onto a truck.

d) Transport to Stripping Point: The latter may be a hand-trimming bench in a packhouse; or a machine stripper in a packhouse, on the field headland, or on a trailer moving up and down the field.

An increasingly popular method of harvesting, especially with larger growers, is the use of the so-called 'sprout combines'. Sprouts should be solid and their outer leaves should be tightly clasping and not yellow in color. Sprouts with small, loose leaves at the base are considered to be of medium quality, while those with many loose leaves and an open top are of poor quality. The sprouts should preferably be dark green, as they retain their attractive appearance longer than do light green ones.

Cauliflower

As soon as the curd becomes visible, it should be

covered to prevent it from turning yellow. Generally, this is done by tying the large wrapper leaves together at the top.

Cauliflowers are harvested before the curds grow loose, generally some days after they have become visible. The length of the harvesting period depends on the weather.

The size of the curds varies widely with the growing conditions, the largest curds attaining a diameter of 30 or more cm. Early cauliflower is generally smaller than late cauliflower. Frequently, preference is given to medium sized curds between 15 and 25 cm in diameter, while those under 10 cm are unacceptable.

More important than the size of the curd is its quality. A good curd must be regular in shape, globular, firm and white in color. Bracts and riceyness cause an inferior product.

Curds are sometimes marketed without foliage, but it is better to harvest them with a whorl of leaves still attached for protection. When the cauliflowers are to be transported in flat crates, the upper part of the foliage is generally removed. As a rule the heads are packed in a single layer, to reduce the risk of damage. When the heads are to be transported loose or in high crates, as little foliage as possible should be cut away.

Broccoli

It is vitally important that broccoli should be harvested at the correct time: the heads must be picked before the buds open and when the bud-clusters are still compact. Yellow buds and loose clusters spoil the product.

The terminal heads mature first. By removing the main head the growth of the lateral head is promoted. As the lateral heads develop unevenly, they cannot all be harvested at one time; indeed in warm weather harvesting is done at least twice a week.

The heads are usually harvested with about 15 cm of the stem attached. After they have been cut off, part of the foliage is removed from the harvested shoots. The heads are from 5−25cm in diameter and weigh from 100 −800g each. Side-shoots are from 5 −10cm in diameter and weigh from 100 −500g each. Broccoli intended for fresh consumption is often sold in bunches weighing about 450 −600g. As the quality of harvested heads soon declines, they should be marketed as soon as possible. Top icing and refrigeration is important.

Storage and Conditioning

Cabbage is most satisfactorily stored at about 0°C and 90% relative humidity. In these conditions, cabbages may be stored for as long as eight months. Cabbages that are destined for storage are trimmed of their outer leaves, while careful handling is of importance to prevent injuring the wrapper leaves.

At 0°C, cauliflower keeps for 2-6 weeks, which can be extended by 1 or 2 weeks if the atmosphere in the storage contains 5% carbon dioxide. Higher concentrations of carbon dioxide cause off-flavors. Cauliflower that is destined for storage is preferably cut earlier than normal; otherwise the curds may separate. If the foliage is not removed, the curd may soon become soft.

Brussels sprouts at 0°C and 90% relative humidity, will keep for at least 3 weeks. At −2°C,sprouts can be stored for a longer period, but have to be thawed slowly later on. Yellow leaflets turn black in storage, even at low temperatures.

After being harvested, heads of broccoli wilt rather rapidly and turn yellow. At low temperatures, the shoots keep from 7 −10 days, whereas at higher temperatures, they may wither after one day.

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Corn

Introduction

Sweet Corn is a member of the Gramineae (the grass family) *Zea mays var rugosa* is an annual grass which can grow up to 4 meters in height. Male flowers are contained in the tassel and female flowers in rows on a thick cob. Sweet corn is distinguished from other corns by its high sugar content when in the milk and early dough stages and by its wrinkled transulucent kernels when dry. It differs genetically by a single recessive gene. Corn is thought to have originated in Mexico and been domesticated over 5000 years ago. Present day varieties of sweet corn had their introduction around the 1850's in the United States.

Sweet corn requires a minimum soil temperature of 10°C for germination and root development. (Soil temperature optimum range 21-27°C). Corn responds well to warm conditions (optimum air temperature 21°- 30°C). Corn growth increases with temperature up to 30°C after which growth response decreases. Corn heat units can be used to assess the normal rate of growth for sweet corn (10°C base temperature). Variety selection based upon corn heat unit requirements to reach expected maturity can be matched to normal corn heat unit values expected at a location. Sweet corn production can be accelerated by planting the seed in plastic covered trenches. This crop is very sensitive to frost but if the growing point is not frozen then the crop may regrow normally. Corn requires a good, even supply of moisture. Irrigation particularly at the time of pollination and early kernel formation may improve quality and yields of this crop. Frost control may be achieved through solid set irrigation systems for corn maturing in late September and early October. Sweet corn produced in more northerly climates is sweeter than that produced in the south.

A well drained soil with good water retention is desirable. Sandy loams, loams and silt loams, high in organic matter, are best suited to this crop. Corn is a shallow rooted crop. Flooding is injurious to corn plants yet water stress is also detrimental to plant development.

Harvest of early sweet corn cultivars occurs in late July, and late corn crops are usually harvested by early October. The peak of the sweet corn season is usually the last week in August when demand and supply are generally the highest. Yields of 2000 to 3000 dozen per hectare are typical (6000 to 10,000 kg per hectare). Early cultivars are lower yielding than late cultivars.

Presently most sweet corn is marketed through roadside stands, farmers markets and delivery directly to retail chain stores. Only a small volume is marketed through wholesale channels. With proper post harvest cooling and more mechanization, development of the wholesale market is possible. There may be some specialty markets for high quality corn such as in the H.R.I. trade.

Nutrient Content: Provides Carbohydrates, potassium and folate; fair amount Vitamin A as well as other nutrients to the diet. 1 ear contains 70 kilocalories, 250 mL (1 cup) kernels contains 148 kilocalories.

Crop Establishment

Early Sweet Corn cultivars need 1900 CHU's mid season cultivars need 2000 to 2100 CHU's and late season cultivars 2200 — 2300 CHU's. Late cultivars can usually be grown successfully in the most favorable climate areas of the Atlantic Region.

Seed Treatment — Do not plant cultivars early which are known not to have seed cold hardiness as seed decay may result in poor stands. (1) Plant when soil temperature is above 18°C. (2) Use seeding rates 20% higher than normal. (3) Plant shallow. (4) Plant into moist ground. (5) Handle seed carefully as kernels can crack easily. (6) The use of plastics usually improves germination. Treatment of seed with a bird repellent should be considered against the removal of the seed and/or plant by birds.

Augmented-Sugar Cultivars — Se and SH2 are two different genes used by sweet corn breeders to increase the sugar level of some of the new cultivars.

These genes also make the corn retain its sweetness longer. You may hear the term "super sweet"; this refers to cultivars with the SH2 gene.

All these new cultivars express their high sugar levels best when grown in isolation, away from both field corn and regular sweet corn. Isolation is most critical with cultivars containing the SH2 gene: e.g. Crisp and Sweet. Isolation can be obtained by growing these cultivars 75 metres away from other corn. These cultivars can also be considered isolated if the corn grown within 75 metres has a 2-week difference in tasseling time.

In scheduling a supply of corn for an extended market period, it is usually preferable to plant a num-

ber of cultivars which mature at different times, rather than attempting to plant one or two cultivars at different times.

Seeding/Planting — Depth of seeding should be no greater than is required to maintain a cover until emergence usually 1 - 2.5 cm, depending on the soil type. Row spacings are usually determined by equipment, closer row spacings usually results in increased yields, provided moisture and fertility are not limited. Too close a spacing between plants reduces ear size and may result in no marketable ears in crowded stands. For early cultivars, rows should be about 75 cm apart, and plants 15 to 20 cm. For tall, late cultivars, rows about 90 cm apart, and plants 20 to 30 cm. Depending on the seed size this usually requires 11 to 17 kg of seed per hectare to produce 50,000 to 85,000 plants per hectare.

Crop Management

Clear plastic mulch can be used to advance the maturity of the corn by 10 to 14 days. Germination and yields are usually increased. Prepare the seed bed, apply fertilizer, work broadcast fertilizer deep enough to allow for trench depth, make trenches, sow seed in the bottom of the trench, band some fertilizer at seeding if desired, apply a herbicide and then cover with the plastic mulch. Two rows spaced about 40 cm apart are usually covered with a strip of plastic 1.2 m wide, pairs of rows are then spaced 1.5 to 2 m apart depending on the equipment. Seed is planted in furrows 10 cm deep and about 15 cm wide at the top. This allows space for plants to grow until the plastic is removed. Some holes about 1 cm in diameter should be made in the plastic to allow rain to penetrate and provide some ventilation. This is usually done by drilling into the roll to coincide with the seeded rows. The plastic is removed soon after the plants come in contact with the mulch.

Do not use high levels of residual herbicides on this crop if field rotation is planned the following year.

Cut corn stubble with a rotary mower while the corn stalks are still green and plow this green material into the soil. Establish a cover or green manure crop if possible to stop erosion and/or provide more green manure.

Nutrition

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Sweet corn requires high fertilization. Manure is a valuable material and 20 to 40 tonnes of manure per hectare may advantageously be substituted for part of the fertilizer.

Lime — Lime should be applied to maintain the soil pH in the range 6.0 to 6.8 for best results. Corn will tolerate a pH as low as 5.5 where the soil contains good levels of calcium and magnesium.

Nitrogen — is the element usually most limiting crop quality and yields. Manures and moderate levels of nitrogen should be applied preplant. The maximum level of N plus K banded is 80 kg per hectare (actual). Nitrogen may be sidedressed but should be done early (before plant is 30 cm high). The corn plant's potential is determined at an early age.

Phosphorus — At least 50 kg per hectare of phosphorus should be banded. This will encourage earliness of production and increase the yield potential.

Potash — Response of corn to potash is that with adequate feedings ears are better filled to the tips and stalk strength is increased.

Magnesium — is a common deficiency and can be corrected by applying sprays of epsom salts (magnesium sulphate) at 5.5 kg per hectare. This should not be necessary on fields properly limed with dolomitic limestone.

Sulfur — where high rates of manures are not used on sandy soils with low organic matters one should consider the use of gypsum to supply an adequate soil level of sulfur.

Micronutrients — *Zinc* deficiency occurs in this region especially with cold wet springs and in fields low soil organic matter, poor soil structure, and high levels of phosphorus. Where zinc is required it may be applied to the soil mixed in the fertilizer at rates supplying 4 to 12 kg zinc per hectare. The higher rate should be sufficient for up to 3 years. Not more than 4 kg of zinc per hectare should be banded at seeding. Zinc may be applied as a spray at rates supplying 0.6 kg of zinc per 1000 L of water. A wetting agent should be added.

Boron deficiency may be a problem on coarse sandy fields with a high pH and low organic matters where boron has not been applied on rotational crops. Care must be taken that the crop is not injured by a soil or foliar application of boron. (Use .1B in the fertilizer)

Application Method — A portion of the nitrogen and phosphorus required should be applied at seeding in one of two ways:

(1) In a band 5 cm to the side and 5 cm below the seed. The rate of application in a band should not supply more than 75 kg nitrogen per hectare or a total of 120 kg of nitrogen plus potash per hectare in 75 cm rows. If urea is the nitrogen source, not more than 40 kg nitrogen or 80 kg of nitrogen plus potash per hectare should be applied, in 75 cm rows.

(2) In a band directly with the seed. With this placement not more than 9 kg nitrogen plus potash (K_2O) per hectare should be applied, in 75 cm rows. A major portion of the nitrogen should be applied preplant or sidedressed before the corn is 30 cm high. A major part of the phosphate and potash may be broadcast and worked in before seeding in the spring.

Pests and Pest Control

Weeds

Excellent weed control is possible in corn through the proper selection and use of herbicides.

When plastic mulches are used, preplant incorporated herbicides are usually not deep enough to control weeds germinating from the bottom of the trench, therefore a preemergence herbicide must be used. The herbicide Bladex has injured sweet corn grown under plastic mulch when excessive rainfall has caused flooding of the trenches.

An over reliance on atrazine alone will encourage the buildup of resistant weeds, especially annual grasses. To avoid this, growers should use an annual grass herbicide in conjunction with atrazine and practice crop rotation. The application of high rates of atrazine or simazine will result in residues in the soil that will cause injury on most rotational crops.

Diseases

Leaf Diseases

— Rust and Eyespot (fungi)

Characteristics: Rust begins as small raised pustules scattered over both surfaces of the leaves. The pustules rupture, exposing dusty, red spores and later black spores. The red spores are spread by wind and can infect leaves directly. The eyespot fungus causes small, elongated lesions with distinct yellow halo's. This fungus overwinters in corn debris.

Control: Damage is often light. Practice clean plowing to encourage rapid rotting of corn debris and rotate with other crops to help prevent disease build-up. Maintain high soil fertility and adequate weed control.

Common Smut (fungus)

Characteristics: Common Smut causes glistening silver-white galls on ears, stalks, leaves or tassels. The interior of the galls turns into masses of powdery dark brown material (spores).

Control: Infected plants should be removed and burned as soon as they are detected.

Insects

Seed Corn Maggot

Characteristics: Small yellowish-white maggots .6 cm long with a pointed head end. The adult is a small grayish-brown fly. Maggots feed on seed, causing seed to produce a poor plant. They will also feed on roots; causing poor plant growth. Seed corn maggots frequently attack deeply planted seeds.

Control: To prevent damage, sow seeds shallow in warm soil or apply a grandular insecticide in furrow when planting to protect seed or use treated seed.

Wireworm

Characteristics: Early in the spring, adult wireworms (click beetles) lay their eggs around grass roots. The larvae hatch in about one week and will live for 2-6 years in the ground feeding on roots and seeds. The wireworms, or larvae, are yellow, white or darker shades of brown. They may be 1.2 to 4 cm long and have a hard, smooth surface. When a larvae is mature, it pupates in the fall. It then becomes an adult beetle and waits until spring to emerge. Wireworms are often numerous in land that has been in sod for several years. See Appendix III in the supplement to this guide. Wireworms are sometimes confused with millipedes which have numerous pairs of legs and coil up when disturbed.

Control: Avoid planting crops highly susceptible to wireworms in a field that has been recently in sod. Plant treated seed.

European Corn Borer

Characteristics: The European corn borer is a flesh colored caterpillar, 2.5 cm long with brown spots and a dark brown head. The eggs are laid in clusters on corn plants. After they hatch, the larvae move to the tassel of the plant. The tassel frequently "breaks" (bends over sharply) because it has been tunneled. The larvae then move down the stalk and enter either the side of the cob or the stalk itself. Damage to the ear makes it unsaleable.

Control: The corn borer can be controlled culturally by removing old stalks from the field to prevent overwintering and practicing crop rotations. Fall plowing is also beneficial.

Corn Earworm

Characteristics: Corn earworms vary in color from light yellow to green or brown. They have a yellow head and grow to almost 5 cm in length. The adult moths are carried in on high winds from the southeastern U.S. They lay their eggs on fresh silks coming from the ear. The larvae climb up the silk and feed on the developing kernels. The corn earworm can be confused with the fall armyworm.

Control: Control is best effected by applying an insecticide 2 days after the first silks appear. This must be repeated at 3 to 5 day intervals or as necessary until the silks dry off. Spray should be directed to wet the silks.

Fall Armyworm

Characteristics: The larvae are generally tan colored, with stripes, smooth skin, indistinguishable from corn earworm. Early injury in whorls causes tattered leaves; later injury is confined to the tassels and ears with feeding on kernels at tip and base of ear. They also invade corn borer tunnels in stalks. The adults are migratory, overwinter in Central America and appear any time after late June. They are generally a greater problem following a cool, wet spring in the South Eastern U.S.

Control: The fall armyworm is controlled by spraying when damage appears on the foliage. Sprays applied for corn earworm control will also prevent fall armyworm injury in ears.

Potato Stem Borer

Characteristics: The potato stem borer, fully grown, is about 4.5 cm long and pinkish-white in color with a brown head. The larvae move from plant to plant increasing the damage. The eggs laid in August do not hatch until June of the following year. Damage can be expected in June and July.

Control: There is, at present, no insecticide that will give good practical control of this insect. Because the moth lays eggs chiefly on couch grass during late August and early September, control of this weed in particular and clean cultivation in general are important preventive measures. Avoid planting corn in narrow strips with grassy margins. Cultivate field boundaries, or spray with a chemical weed killer to reduce couch (quack) grass.

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Harvesting and Handling

Harvest at the thick milk stage. Whenever possible, harvest in the morning when the ears are cool. Market on the day of harvest especially if proper cooling is not practical. Sugar content decreases rapidly after harvest, but less so if the corn is cooled. Rapid lowering of the temperature in the ears (pre-cooling), such as by submersion in ice-water or hydrocooling, is highly desirable.

Storage and Conditioning

Sweet corn quality can be maintained fairly well for 4 to 8 days after harvest at a temperature of -0.5 to 0°C, and a relative humidity of 90 to 95%, after precooling, but should be marketed as soon as possible. Because green corn produces much heat of respiration, it should not be handled or stored in bulk for long periods.

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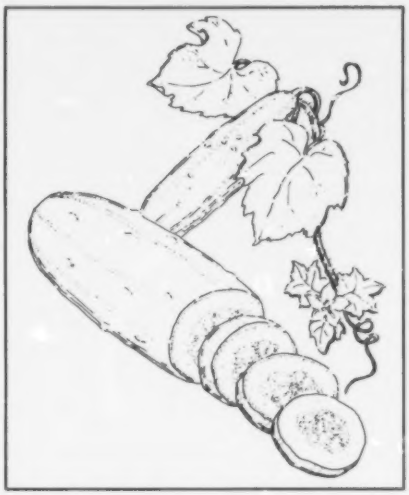
Cucumbers



Introduction

The cucumber belongs to the Cucurbitaceae (gourd family). The cucumber belongs to the genus *Cucumis* of which there are 20 to 25 species found mostly in Asia and Africa. Only two *Cucumis sativus* (cucumber) and *Cucumis melo* (melon, muskmelon and persian melon) are of commercial importance in North America. It is an annual trailing or climbing vine usually with flowers of both sexes on the same plant (monoecious). Current market hybrids are produced on genetically gynoecious lines (all female blooms). Commercial seed lots have up to 10% of a monecious variety to provide sufficient pollen for fruit set. European greenhouse cucumbers set fruit without pollination (parthenocarpic). The cucumber is native to the northwest of India and has been cultivated there for at least 3000 years. The cucumber was known in France in the 9th century and was common in England in 1327.

Cucumbers are very sensitive to cold temperatures and may be killed at 1°C. It has a minimum germination temperature of 16°C, an optimum germination range of 16°C to 35°C, with an optimum germination temperature of 35°C, and a maximum germination temperature of 40°C. Soil temperatures at planting must be at least 10°C for table cultivars and 13°C for gherkin cultivars. Planting must be delayed until all danger of frost is past. Windbreaks are essential for early production of this crop.

A well drained loam to sandy loam soil with high organic matter with no frost pockets or problems with surface drainage is the ideal field situation. Wind protection natural or artifical is necessary.

Slicing cucumbers, with the aid of plastics, are harvested from the field in early to mid July. Most of the field crop does not come on until early August. Slicing cucumbers average 15,000 kg per hectare with some yields as high as 22,000 kg per hectare. Due to market gluts in warm seasons not all of the crop is marketed. (2,500 doz per hectare to 5,000 doz per hectare). Pickling cucumber yields depend on the size of fruit harvested. (15,000 to 17,000 kg per hectare)

Cucumbers are an important crop in the Atlantic area though market potentials are not large. On the fresh side there is a strong demand for the product as it is a salad vegetable but processing cucumber markets have shrunk in the last few years. The greatest potential would seem to be to extend the season by earlier production (use of plastics) and to look for speciality markets.

Nutrient Content: Contains fair amounts of potassium, calcium and folate; and small amounts of other nutrients including Vitamin C. Very low in calories. 6 slices contains 5 kilocalories.

Crop Establishment

Seed Treatment — seed may be pelleted to facilitate planting with precision seeders. Often though raw seed is used with non precision seeders.

Transplant production — crops for early harvest are usually planted in peat pellets, peat blocks or peat pots. Plant 3 seeds per cell and then thin to 2 plants. This crop does not take the transplant shock of bare roots. These plants are best grown on an artificial soil mix. Young plants with 1-2 true leaves are the best for field setting. The peat pots must be well soaked and must be completely buried when transplanted to prevent excessive drying of the soil in the pots. The seeding rate for transplant production is 2.2 kg per hectare.

Seeding/Planting — Approximately 3 to 5 kg of seed per hectare are required for direct seeded crops. Higher populations need more fertilizer and water and are more sensitive to weed competition, but yields per hectare should be higher. Cucumbers should be seeded no deeper than 1.0 to 2.0 cm.

Rows should be spaced 120 to 180 cm apart with plants 20 to 30 cm apart. The present trend is toward higher plant populations per hectare by closer spacing of the rows.

With direct seeding, seed outdoors when the ground has warmed, and danger of frost has passed. A second planting may be made beside the first a few days later if germination is doubtful to ensure the earliest possible satisfactory stand. One planting can be destroyed later if not required. Seed may be sown 2 or 3 weeks earlier under hotcaps or under row tunnels.

Crop Management

Transplants — Early cucumbers which have been started in containers are not usually field set until mid to late June (3-4 weeks after planting). Row covers or hotcaps will protect the tender plants from cold and wind injury during the first 2 or 3 weeks in the field. The covers should be removed gradually.

Plastic Mulching — Mulching transplants or seeding directly through mulches or black polyethylene has been proven beneficial because of an increase in early and total yield. These mulches also conserve moisture, control weeds, accelerate maturity by increasing soil temperature and reduce fruit rots. The plastic should fit snugly against the soil surface. Do not lay plastic on dry soil, either irrigate or wait for rain.

The polythylene films are usually black or some other dark color in order to control weeds. If a clear film is used, a preemergence herbicide must be applied to the soil before laying the mulch. Clear mulches have been shown to be more effective at increasing yields due to the higher soil temperatures they achieve. Commercial machines are available to transplant plants in peat pots through the mulch. There are also seeders that can plant through the mulch.

When mulches are used less fertilizer may be required as the mulch permits plants better rooting in the surface layer and less nitrogen is lost by leaching.

Early Plant Death — In some growing seasons vine crops of that have been recently transplanted or which have recently germinated, suddenly wilt and die. Most often, this situation occurs during a period of 4 to 5 days of rainy or cloudy weather. Without sunshine, soil temperatures drop below 13°- 16°C. At these temperatures the plant roots cannot absorb water from the soil. Consequently, when the sun does reappear, water transpires from the leaves much more rapidly than the roots absorb water, resulting in the sudden wilting and death. The earlier the planting date the greater the susceptibility to this problem.

Irrigation — returns for pickling cucumbers may increase with proper irrigation. With irrigation, it is possible to ensure more uniform emergence and plant development under dry soil conditions. Weed control chemicals are also more effective when followed by a light irrigation. High plant populations can also be safely grown without losses due to lack of soil moisture. The water needs of a cucumber plant are most sensitive during the fruit set and development period. Minimize the time foliage is wet to help avoid disease.

Wind — Winds not only damage plants but slow down the rate of growth. If no natural protection is available, strips of corn or fall planted rye can be used. There are also plastic fencing materials currently on the market. Wind protection is provided for a distance equal to ten times the height of the windbreak provided the right porosity (50%) is used. In terms of both artificial and plant windbreaks use them in north-south rows at right angles to the prevailing winds. In the absence of a windbreak, it is preferable to plant rows in the direction of the prevailing wind.

Pollination — Cucumber pollination is accomplished by honey bees, so it is essential to have colonies in or alongside the field. Gynoecious hybrid varieties need at least one colony of honey bees per hectare. Seed of commercial hybrid cultivars usually contain 10-15% monecious seed. This percentage could be lower and there would still be enough male flowers to supply pollen if the male flowers are uniformly dispersed in the field. It is best to place the colonies in the field about 6 days after bloom starts. This ensures that flowering will be sufficient to attract bees into the field. It is important to encourage bees to forage on the cucumber flowers rather than on other plants in the area. Warm, sunny weather will allow pollination for some crops to be completed in less than one week. Insecticides applied to fields will poison honey bees. Notify your beekeeper before application of any pesticide.

Nutrition

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Cucumbers are a crop requiring a moderate amount of fertilizer.

Manure — All vine crops respond well to manure. If available apply 22 to 45 tonnes per hectare and reduce fertilizer proportionately. Most vine crops do well after a sod of perennial forage crop since soil structure is usually at its best.

Lime — Lime to a pH of 6.0 - 6.8.

Nitrogen — Apply at least part of the nitrogen preplant. The remainder of the nitrogen should be sidedressed before the vines begin to run. On sandy soils a second application may be necessary after the vines begin to run, especially following heavy rains. Foliar applications of urea may be used if slicing cucumbers or pickling cucumbers are to have multiple harvests.

Phosphorous — Adequate phosphorous is essential for vine crops. If possible band part of the phosphorous.

Potash — Apply only the required applications either broadcast and incorporated before planting or part may be banded 5 cm to the side and 5 cm below the seed.

Magnesium — If soil magnesium levels are low a fertilizer containing magnesium may be used. Foliar sprays may also be used.

Sulfur — On sandy soils with low organic matter that have been intensively cropped soil sulphate levels may be low. Application of gypsum should be considered on these soils.

Application Method: Up to 100 kg of (N + K) per hectare can be applied in a band, 5 cm to the side and 5 cm below the seed at planting with the remainder of the fertilizer broadcast before planting. Nitrogen may also be sidedressed or applied to the foliage.

Pests and Pest Control

Weeds

Herbicides registered for use on cucumbers do not provide total, season long control. Successful

weed control requires integrating cultural and chemical methods. Preplanting control of perennial weeds is essential. Cucumbers should be planted to land where the annual weed seed population has been reduced by cultural procedures such as crop rotation, summer fallowing or stale seedbed. Cultivation will be required to supplement chemical weed control.

Many growers use plastic mulch in the production of cucumbers. Opaque plastic can be used to control weeds in the row in main crop cucumbers. Contact your local agriculture office for information on controlling weeds growing between the rows of plastic mulch.

Care must be taken to avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur.

Diseases

Damping off (fungi)

Characteristics: Several fungi may cause damping off. This disease may take several forms including decay of the seed immediately following seeding or germination, and post emergence damping-off where the fungi attacks the stem at the soil line causing a constriction which causes the young seedling to topple over. Damping off fungi may also cause a root rot.

Control: Sow seeds treated with a fungicide. For greenhouse grown plants, sterilize soil (or use an artificial mix) and disinfect work areas, benches, flats, etc. Drench seedlings with an appropriate fungicide.

Leaf Spots

— *Alternaria* (fungus), angular (bacterium)

Characteristics: *Alternaria* causes small circular spots which enlarge up to 2 cm in diameter with dark concentric rings within the spots. Spots coalesce to affect large areas of the leaf.

Angular leaf spot causes small angular spots that are irregular in shape and size. May attack fruit causing water soaked spots. Fruit rot follows. Both organisms overwinter on the seed or in plant residue in the soil.

Control: Follow a 1-2 year rotation. Apply a fungicide at first sign of disease and at 7-10 day intervals. Use an alternating schedule with an organic fungicide for *Alternaria* and fixed copper for angular leaf spot.

Powdery Mildew (fungus)

Characteristics: Appears as a white powdery growth on leaves which may cause leaves to wither and die. It tends to be a problem in some varieties more than others. It is favored by high temperatures.

Control: Resistant cultivars are available. For susceptible cultivars apply an appropriate fungicide at the first sign of the disease and at 7-10 day intervals.

Cucumber Scab (fungus)

Characteristics: A fungal disease which overwinters in seed and in crop residue. Infected fruit will have dry, sunken corky areas up to 1 cm in diameter. Scab areas on leaves will cause misshaped leaves. The disease is brought on by moist, humid conditions and cool night temperatures.

Control: Use resistant cultivars. No cultivar is completely immune so follow a 2 year crop rotation. Effective fungicides are also available.

Bacterial Wilt (Bacterium)

Characteristics: First sign of disease will be wilting of individual leaves. Later, branches or even the entire plant will wilt and eventually die. Bacterial wilt overwinters in the Cucumber Beetle and is transmitted to the plant when the insect feeds.

Control: Apply insecticides to control the cucumber beetles.

Insects

Seed Corn Maggot

Characteristics: Small yellowish-white maggots 6 mm long with a pointed head end. The adult is a small grayish-brown fly. Maggots feed on seed, causing seed to produce a poor plant, and will also feed on roots, causing poor plant growth. Seed corn maggots frequently attack deeply planted seeds.

Control: Plant as shallow as needed in a well prepared seedbed. Early germination is necessary to get good plant stands and prevent injury. Later planted crops are not as susceptible to this pest. Good weather conditions are necessary to completely control the pest. Avoid planting susceptible crops in fields very recently manured. Chemical seed treatment is essential.

Cutworms

Characteristics: Cutworms are dull colored, soft bodied caterpillars found at the base of plants, just under the soil level. They feed on seedlings, cutting them at soil level or just below.

Control: See Appendix II of the supplement.

Cucumber Beetle

Characteristics: The striped cucumber beetle overwinters in the adult stage under leaves or dense grass, emerging in May or early June. The adult is 5 mm long. Its upper surface is about equally black and yellow, with the folded wing covers bearing three black stripes. Two weeks after emerging, the beetles mate and lay eggs. The orange-yellow eggs are laid in the soil at the base of host plants and hatch within 10 days. Upon hatching, the larvae burrow into the soil and start to feed on roots. Two weeks later, a new generation of beetles appear. In Canada, there is only a single generation per year. They are a carrier of bacterial wilt.

Control: Apply insecticides when insects first appear and repeat as necessary.

Two-Spotted Spider Mite

Characteristics: An occasional pest but when it does occur, it can be serious. Leaves become speck-

led and then turn bronzed or brown. A fine webbing is produced on the underside of the leaves. The mites are microscopic in size. Usually this pest only becomes a problem under very hot dry weather conditions.

Control: Apply appropriate miticide.

Tarnished Plant Bug

Characteristics: Small 6 mm long insect, mottled white and yellow with touch of black on wings. Nymph is very small, greenish-yellow and marked with black dots on the thorax and abdomen. They overwinter under bark or leaf-litter, emerging early in the spring and feeding on weeds and fruit buds. After mating, eggs are laid on stems and petioles. Nymphs (yellowish-green, 1 mm long) emerge after 10 days, undergoing two molts to become adults within 3-4 weeks. Adults and nymphs are equally damaging.

Control: Apply insecticides when insects first appear and repeat as necessary.

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Harvesting and Handling

Fruits of slicers should be harvested before the seeds become too well developed. This is usually while the fruits are still a little rough. Do not allow any fruits to remain and form seed on the vines, because production of new fruit will be reduced. Picklers should be harvested regularly, to market or processor size requirements.

Impacts and pressure during handling can cause serious damage to pickles which cannot be seen because it is internal. This internal damage increases bloating during brining and drastically lowers the value of the pickles. All key operations such as loading, hauling, unloading and grading influence the quality of pickles that go into the processing plant.

Minimize or eliminate the dropping of cucumbers whenever possible. Bruising and breakage of cucumbers is influenced by the height of discharge above the collection source (e.g. basket, bin or truck). Research indicates that a 75 cm drop on a hard surface causes visible internal fractures. Every effort should be made to reduce the number and height of drops. Foam rubber (7-8 cm minimum) on the floor of transport vehicles drastically reduces the otherwise severe damage to the first few layers of fruit. If cucumbers are piled deep in transport vehicles, the likelihood of damage increases.

Storage and Conditioning

The recommended storage temperature is 7 to 10°C at a relative humidity of 95%. Even under these conditions, cucumbers cannot be expected to keep satisfactorily for more than 2-3 weeks. Chilling injury develops rapidly at temperatures below 7°C, and above 10°C ripening and yellowing occurs. Once pulled the cucumbers should be cooled as quickly as possible.

Pickling cucumbers are normally stored for long periods of time in brine solution. If, however, fresh pickles need to be stored or held for a short period of time before being processed or placed in brine tanks, the cucumbers should be cooled as rapidly as possible to 7 - 10°C. Hydrocooling has been used successfully to remove field heat. Holding cucumbers at higher temperatures will cause a rapid loss of green color. Loss of color will also occur more rapidly if held in the same room with apples, tomatoes or other ethylene producing crops. Humidity should be as high as possible to prevent shriveling.

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(See also General References)

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Lettuce

Introduction

Lettuce belongs to the Compositae (sunflower or daisy family). *Lactuca sativa*. It is an annual plant native to the Mediterranean area. Cultivation may have started as early as 4500 BC, perhaps initially for the edible oil extracted from its seeds. Salad lettuce was popular with the Ancient Greeks and Romans. Cultivated lettuce was probably derived from the so called wild or prickley, lettuce *Lactuca sierriola*. The primitive forms of lettuce were loose and leafy. Firm heading forms became well developed in Europe by the 16th Century. Oak leaved and curled-leaf types of various colors were described in the 16th and 17th centuries in Europe. There are 5 types of lettuce (1) Crisphead (2) butterhead (3) Cos or Romaine (4) loose leaf or bunching and (5) stem lettuce (celtuce).

Head lettuce grows best at 15 - 18°C. Germination takes place at a minimum of 5°C, has an optimum range of 16 to 20°C, and an optimum germination temperature of 20°C (depending on the cultivar and type of lettuce). Hardened seedlings are tolerant (− 5°C to − 7°C) to frost but mature plants are more sensitive to frost (− 1 °C) depending on the cultivar. Warm and dry conditions promote flowing and seed formation (bolting). Bolting occurs where temperatures over 20°C are maintained day and night. Also tip burn problems are serious under this situation as is bitter flavor. Cool nights are essential for quality lettuce. In the Atlantic area it would seem the early soils in the St. John River Valley and the Annapolis Valley are best suited to early lettuce production (June and July marketings) and that coastal areas would be best suited for July, August, September and October production.

Warm sandy soils are preferred for the early harvest, loam to clay loam or peat for late production. Good drainage and high organic matter content are essential. A regular supply of water is essential although high humidities and excess water close to the time of harvest can be destructive to the yield and quality of the crop. Fields low in disease must be selected. Sclerotinia drop has been the most serious production problem in the development of head lettuce.

Leaf lettuce is produced in tunnel houses and in early field stands from the last week of May until late June. This crop can be produced from late May to October but markets are generally early in the season (before head lettuce is available), or for specialty markets in the H.R.I. Trade. Yields depend on the row spacing as well as size of the required product — 2000 dozen to 3000 dozen per hectare (500 g per head). Head lettuce for the early market is usually transplanted in late April or Early May for harvest in mid to late June. Head lettuce may be transplanted up to early August depending on the variety and the market. Yields of 2000 dozen per hectare is average and individual fields may yield 3000 dozen per hectare (500 g to 1000 g per head). Romaine lettuce scheduling and yields are similar to head lettuce except that cos lettuce may be grown in tunnel houses for an early crop during the same time period as leaf lettuce (from late May on).

Lettuce is currently an important crop which once was grown in larger quantities in the Atlantic Area. The area of Romaine and head lettuce has started to increase but it has a long way to go to replace imports. Lettuce is the vegetable which is imported in the largest volume and has the largest dollar value of any vegetable imported into the Atlantic Area during the time it can be produced here. Currently most marketings are through roadside markets or deliveries direct to retail stores and small wholesalers. If we can control sclerotinia drop, and get adequate cooling equipment we should be able to grow head lettuce successfully.

Nutrient Content: Useful amounts of several nutrients including Vitamins A and C; and minerals calcium and iron. The nutrient content is highest in the darker green, outer leaves. Low in calories. Each head contains 65-70 kilocalories.

Crop Establishment

Seed Treatment — Lettuce germinates best at relatively cool temperatures. This crop should be pregerminated in cool rooms during the summer (seeded in modules or peat blocks) as conditions are generally too hot for good germination even if greenhouses are well ventilated.

Seeding/Planting — Begin field seeding as soon as the land can be worked. A succession of seedlings are necessary for continuous cropping in those coastal areas where lettuce can be grown throughout the summer and early fall. Coated or pelleted seed is available so precision seeders may be used. Seed sparsely to reduce thinning. Thin when two or three leaves have

formed. Weed control is usually more of a problem with direct seeded fields.

Approximately 275 g of seed will provide transplants for one hectare. Direct seeding requires 1 to 2 kg per hectare unless precision seeded. Lettuce should be seeded at a depth of 0.6 cm or less.

Space rows 30 cm or more apart as determined by machinery. Plants should be spaced 25 to 36 cm apart for head lettuce, and 20 to 30 cm apart for leaf and bib lettuce. Seed sparsely to reduce thinning. Thin when 2 or 3 true leaves have formed.

For transplanting seed is usually sown in the greenhouse in early March, 6 to 8 weeks before field planting. Seedlings are transplanted two weeks later into flats with a 4 to 5 cm spacing, into peat pots, peat blocks or plant bands. Module trays may also be directly seeded or transplanted. Plants should be hardened for a week to 10 days before field setting.

Thoroughly soak the soil in the flats with starter solution before transplanting. Keep as much soil as possible on the roots. When transplanting to the field, do not set the plants too deep in the soil or small pointed heads may result.

Crop Management

Beds — Lettuce should be transplanted or seeded on raised beds if possible.

Irrigation — A steady supply of moisture is needed for good quality and yields. Irrigation must be monitered along with the weather especially when the crop is approaching maturity since excessive moisture may ruin the crop.

Plastic — Plastic mulches provide a barrier between the soil and the plant foliage. This reduces the potential for plant disease. If black plastic is used, weeds are also controlled. For those growers producing specialty lettuce for the H.R.I. trade plastic mulches should be considered.

Plastic tunnels may be used for early leaf and romaine lettuce production. Transplants would be set into these structures in mid April. Plans are available from your local vegetable extension specialists.

Nutrition

ALL ADDITIONS OF LIME AND FERTILIZER OR MANURES SHOULD BE BASED ON RECOMMENDATIONS FROM A SOIL TEST. WHEN TEST RESULTS ARE NOT AVAILABLE THE GENERAL REQUIREMENTS FROM TABLES 1 - 4 OF THE SOIL AND WATER MANAGEMENT SECTION OF THIS GUIDE MAY BE FOLLOWED.

Lettuce would seem to require moderate amounts of soil fertility. Little research has been done in the Atlantic Area on lettuce fertility.

Manure — manures are generally not recommended due to its weed seed content and the lack of good selective herbicides registered on this crop.

Lime — should be applied to maintain a soil pH in the range 6.0 to 6.8. On peat soils the pH for optimum crop performance is 5.5 to 6.0.

Nitrogen — Half of the nitrogen may be broadcast before planting and worked into the soil. The balance is sidedressed 3 weeks after transplanting the crop or after thinning of the seeded crop.

Phosphorus — is usually broadcast before planting and worked into the soil but should be banded if possible.

Potash — should be broadcast and incorporated before planting. Lettuce is quite tolerant of salt damage so small amounts of potash may also be banded.

Sulfur — is suggested on soils low in organic matter which are being intensively cropped. Generally these are sandy soils.

Micronutrients — *Boron, copper* and *molybdenum* applications are required in organic or peat soils. Boron may be beneficial on some mineral soils. Use .2 to .3B in the fertilizer). Minor elements are most conveniently applied in the fertilizer but may be sprayed on the soil and incorporated before planting or applied as a foliar spray to the crop itself.

Application Method — Broadcast before planting and work in, or preferably band 5 cm below and 5 cm to one side of the seed row. Lettuce with its limited root system, is considered to be a poor feeder.

Pests and Pest Control

Weeds

Herbicides recommended for use on lettuce will not provide total, season long weed control. Good weed control requires integration of cultural and chemical methods. Lettuce should be planted to land free of perennial weeds, where the annual weed seed population has been reduced by cultural practices such as crop rotation, fallowing or stale seedbed. Herbicides should be ordered early to avoid problems of short supply at planting. Care must be taken to avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur.

Diseases

Gray Mold - (Botrytis) fungus

Characteristics: Gray mold can appear on plants at all stages although initial infection is often on seedlings in the greenhouse. Seedlings look like they have damping off; while older plants rot at the stem or on lower leaves in contact with soil. A slimy rot spread upwards into the head. A dense fuzzy gray mold appears on infected areas and dark, hard sclerotia (fruiting bodies) may also develop. Disease spreads mostly under moist conditions.

Control: Seed should be dressed with suitable fungicide. Use sterile seedbeds and flats and avoid thick stands of seedlings and transplants. Spray at weekly intervals. Use a 3 or 4 year crop rotation. Plow down crop refuse promptly after harvest.

Lettuce drop - (Sclerotinia) fungus

Characteristics: Symptoms begin on the stem near the soil surface. A severe wet rot develops rapidly and spreads downward to roots and upward through the head. Once the base of the leaf is rotted, the leaf

wilts, withers and dies. Symptoms successively develop from outer to inner leaves. The head becomes a wet, slimy mass. During wet conditions, a white cottony mold develops on rotted plant parts; hard irregular black sclerotia (pea sized bodies) may occur in the mold.

Control: Sclerotia can persist for many years in the soil. Wet conditions favour disease. Avoid, if possible, land where beans, lettuce, peas, tomatoes, carrots, cucurbits or cabbage have been grown recently. Practice a 3-year rotation with non-susceptible crops (grasses, corn, cereals, onions or beets). After harvest, disc the field promptly.

Downy Mildew - (fungus)

Characteristics: Usually only a problem in coastal areas. Downy mildew can affect seedlings or mature plants. Symptoms appear first on oldest leaves. Yellowish or light-green blotchy areas appear on the upper sides of leaves. A white, downy mold then appears on the undersides of the leaf spots; finally, the affected areas die. The fungus overwinters in crop residue. Spores are spread by wind. Spore production is greatest at temperatures below 19°C and at relative humidities approaching 100%.

Control: At first sign of disease, spray with a fungicide at 7-10 day intervals, using a spreader-sticker. Carry out a 2 to 3 year rotation. "Calmar" has some resistance.

Rhizoctonia Bottom Rot (fungus)

Characteristics: Infection occurs on lower leaves touching the ground. The disease progresses up into the head causing a dark brown, slimy decay. Later the head may dry out leaving a dry, mummified plant. The pathogen lives indefinitely in the soil.

Control: Avoid rotating potatoes and other susceptible crops with lettuce. Grow lettuce on 8-15 cm high ridges. Plow down crop residue immediately after harvest.

Aster yellows - (mycoplasma)

Characteristics: Yellowing and curling occur on the youngest leaves. At heading, head leaves are dwarfed and curled and heads remain soft. The mycoplasma can overwinter in many perennial weeds and is spread to lettuce by leafhoppers during their feeding.

Control: Eliminate weed hosts. Do not plant lettuce adjacent to earlier lettuce plantings that contain infected plants. Grain or grass crops should not be planted close to lettuce. Apply controls for the leafhopper vector.

Slime

Characteristics: A physiological disease of hot, humid weather, often aided by bacteria. The greatest single danger to mature lettuce, it produces a wet, slimy decay on lettuce in the field, in transit or in the market. Usually the large, internal leaves are affected first.

Control: Aim for a sequence of harvests at optional maturity by successive sowings. Do not overcrowd plants and avoid overwatering. Harvest as soon as mature, pre-cool heads to 1°C and keep them cool.

Insects

Cutworms

Characteristics: Cutworms are common pests in the Atlantic Provinces. Most of the damage is to newly set plants in the field. Plants are commonly cut off at ground level but some species can climb and feed on the lower leaves of the plants.

Control: See Appendix III of publication 1400A.

Aster (six-spotted) leafhopper

Characteristics: The leafhoppers can carry aster yellows from plant to plant as they feed. They are small (4 mm long), slender, wedge-shaped insects. They are greenish-yellow in color. Once a leafhopper feeds on an infected plant, it can spread it to all the other plants it feeds on. They feed on many other crops such as potatoes, tomatoes, celery, spinach, lettuce, onion and squash.

Control: Planting time treatments include granular or soil-injected insecticides. Alternatively, spraying regularly throughout the season can be done. Spray crop and field boundaries at weekly or twice-weekly intervals from time of transplanting or emergence of seedlings. Twice-weekly applications are only necessary during periods of heavy infestation, usually during late July and early August.

Aphids

Characteristics: Aphids are small, soft-bodied, slow-moving insects. They are often found in large colonies on the undersurface of leaves. A colony consists of winged and wingless adults and various sizes of nymphs. Aphids may be black, yellow or pink, but mostly are various shades of green. Lettuce aphids are small, green or pinkish and feed on the inner leaves and within the heads. Other aphids feed on the undersides of leaves and curl or stunt them. Some aphids will also feed on the roots thereby stunting the plants.

Control: Use granular insecticides and/or foliar insecticides as necessary.

Slugs

Characteristics: Slugs eat the leaves of the crop and cover it with unsightly slime tracks.

Control: Baits containing metaldehyde, a specific poison for slugs, can be used but are considered too costly in commercial plantings. Slugs prefer areas which are cool, moist and high in organic matter. Sod crops, weedy fence lines and hedgerows fulfil these conditions. Since slugs can over-winter fairly easily, cultural practices aimed at controlling them should begin at least one year before the susceptible crop is put in.

SPECIFIC CHEMICAL CONTROLS FOR THE VARIOUS CROP PESTS DISCUSSED MAY BE FOUND IN

THE SUPPLEMENT TO THIS GUIDE, A.P.A.S.C.C. PUBLICATION 1400A, "A GUIDE TO CULTIVAR SELECTION AND CHEMICAL PEST CONTROL FOR VEGETABLE CROPS."

Harvesting and Handling

Harvest leaf lettuce as soon as the plants are large enough.

Harvest head lettuce as soon as heads become firm. Harvest early in the morning, if possible, and keep cool until marketed.

Storage and Conditioning

Rapidly cooled lettuce in good condition can be stored for 2 to 3 weeks at a temperature of 0°C, and a relative humidity of 95% or over. Vacuum cooling is the best treatment for quickly removing field heat to temperatures near 0°C, and this is effective in extending the storage life of this vegetable.

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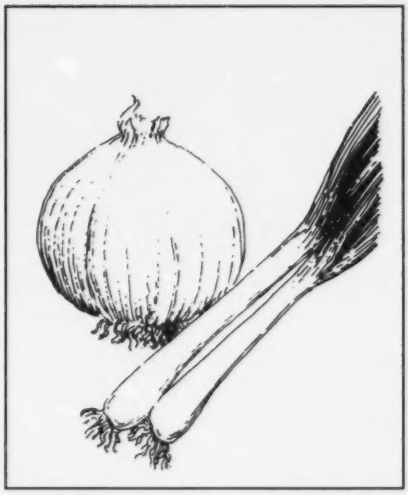
Onions



Introduction

The common dry yellow onion belongs to the Amaryllidaceae (Amaryllis family). *Allium Cepa* is related to a great number of other species of similar odor and taste — garlic, leek, chive, welsh onion. The shallot is considered a form of *A. cepa*. Asia is considered the centre of origin — Northwestern India, Afghanistan, parts of the USSR and China. The onion has been known and cultivated from the earliest period of history (for at least 5000 years). Onion culture spread into Northern Europe in the Middle Ages.

Onions are a cool season crop. The germination of onions is slow at 6-7°C, the optimum germination temperature range is 10-35°C, and the maximum temperature is 40°C. The onion crop is adapted to a growing season with air temperatures at 13-24°C. Low temperatures early in the season are desirable with higher temperatures after bulb formation. The onion is tolerant of frost but seedlings are generally only tolerant down to −1°C. High soil moisture is desirable due to its relatively small root system.

Onions are sensitive to photoperiod. Long days are favorable to onion production as this enhances leaf development and formation which, in turn, is directly related to bulb size. Early varieties require 13 hours for bulb initiation while late varieties require 16 hours for bulb initiation.

Onions begin to form bulbs when day length reaches the appropriate duration for the cultivar, providing temperatures are high enough. Early seeding or transplanting is therefore essential. Cool weather during early growth of the plant promotes formation of seed stalks (bolting). The onion bulbs quicker in warm than at cool temperatures. At 40°C bulbing is retarded. In the onion there is an interaction between day length and temperature in the bulbing process of an individual cultivar.

Onion soils should be well drained and well supplied with organic matter. Sandy loams and loams without stones are optimal. Heavy clay and coarse sand should be avoided.

Early onions are grown from sets sown in mid to late April. These stands mature in late August and early September and are marketed. Usually these are "Stuttgarter". Onions from seed do not usually mature until mid to late September. (Onions started from transplants mature about the same time as sets.)

Bunching onions may be planted in August and overwintered. Bunching onions also may be planted in the spring for harvest in late July and August. It is possible tunnel houses could be used to extend the season on bunching onions. Spanish onions are grown from transplants as they take a long time to mature. Yellow onion yields range from 18,000 to 40,000 kg per hectare. Green bunching onions yield 20,000 - 24,000 kg per hectare.

There are relatively large markets for yellow onions (including spanish) for both fresh and processing in the Atlantic Area. There may be export markets as well to compliment seed potatoes being exported (to make up shiploads). More onions of all types could be grown for roadside market sales and for speciality items for the Hotel, Restaurant & Institutional Trade.

Nutrient Content: One medium raw onion supplies 40 kilocalories. It contains Vitamin C, potassium and calcium plus trace amounts of other nutrients.

Crop Establishment

Onions are established in many ways: from seed, transplants, multiple transplants, sets, and overwintered.

Seed Treatment — Onion seeds may be pelleted for precision seeding. This type of seeding produces more uniform size, less culls and higher yields.

Seeding/Planting — Seed in two lines 7.5 cm apart in the row with 40 seeds per meter of row. For beds at 1.7 to 1.8 m five rows may be seeded.

Spanish onions may be transplanted 10 cm apart in rows or beds appropriate to available equipment.

Sow seed as early as possible. Seed of some cultivars of bunching onions, sown in the fall, produce small plants which overwinter in milder coastal areas and produce an early crop in the spring. Sweet Spanish cultivars should be greenhouse seeded in late February for transplanting in early May.

Approximately 4 kg of raw seed is required for dry onions which are not precision seeded. 6 kg of seed is required for bunching onions and 35 to 45 kg per hectare is required for pickling onions. For growing sets, sow seed 60 to 70 kg per hectare in bands. Approximately 2000-4000 kg of sets are required per hectare (depending on the set size).

Seed onions (seed) no deeper than .5 to 1.5 cm.

Crop Management

Irrigation

Onions have a shallow and limited root system which explore only the upper 30 cm of the soil. This crop should be irrigated frequently throughout the growing season. The soil moisture should not be allowed to fall below 50%. Each irrigation should wet the soil to a 60 cm depth. Soil moisture is important in the growth of new roots, the soil moisture must reach the base of the bulb periodically if the newly formed roots from the stem are to grow into the soil. New roots will not grow into dry soil.

Nutrition

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Onions require a highly fertile soil but well balanced.

Manure is not recommended as weeds are a serious problem in this crop and due to the irregular availability of nitrogen.

Lime — Mineral soils must have a pH of 6.5 to 6.8 for satisfactory crops. On peat soils pH of 5.5 is sufficient.

Nitrogen — Apply most of the nitrogen preplant incorporated (at least 2/3 of the required amount). Sidedress the remainder in mid to late June after the seeded onions are about 15 cm tall. Excessive nitrogen especially in July can cause delayed maturity (thick necks) and soft bulbs.

Phosphorus — Should be banded if possible at the time of seeding. Otherwise relatively heavy applicants of phosphorus must be broadcast and preplant incorporated.

Potash — Potash should be broadcast and preplant incorporated. Application rates depend on the level in the soil.

Micronutrients *Copper* — deficiency occurs on acid mineral or peat soils. Copper may be mixed with the fertilizer and applied. On peat soils (as an initial application) 50 kg of copper sulphate per hectare is recommended.

Manganese — At high soil pH's a deficiency may show up. Soil application of this element is not suggested due to the large amounts required. Foliar applications of manganese sulphate are recommended, starting when the plants are about 15 cm tall with 1.5 to 2.75 kg manganese per 1000 L of water and repeated in 4 to 5 sprays 10 days apart. Use the low rate on small plants increasing the rate as the season progresses.

Molybdenum deficiency may occur when onions are grown on acid mineral or peat soils. A seed treatment has proven beneficial. The treatment is accomplished by dissolving 15 grams of sodium molybdate in 45 mL of water. Spray this solution from an atomizer bottle on 2.3 kg seed spread thinly on a plastic sheet. Do not use excessive water as this can cause the chemical to penetrate the seed embryo and cause injury. Mix the seed thoroughly and let dry. Spraying the plants with sodium molybdate at rates supplying 0.1 to 0.25 kg molybdenum per 1000 L also will help to avoid deficiency symptoms. On peat soils apply an initial application of 10 kg of either ammonium molybdate or sodium molybdate per hectare.

Zinc — If zinc becomes a problem spray the foliage with zinc sulphate at rates supplying 0.6 kg zinc per 1000 L of water.

Boron — On peat soils an initial application of 1.5 kg of actual boron is recommended. On high pH sandy soils with low organic matter and where boron has not been used on rotational crops one foliar spray of boron may be considered.

Application Method — Generally N, P & K is broadcast and preplant incorporated. N P & K may be partly banded. Nitrogen may be sidedressed early in the season. Foliar sprays may be used for micronutrient applications.

Pests and Pest Control

Weeds

Onions do not compete well with weeds. Good weed control requires integration of cultural and chemical techniques. Herbicides will provide preemergence and postemergence control of annual weeds but repeat applications may be necessary. Cultivation and hand weeding are usually required to supplement chemical control. Onions should be planted in soil where the annual weed seed population has been reduced by cultural procedures such as crop rotation, fallowing or stale seedbed.

Onions can be successfully grown in opaque plastic mulch. This method provides excellent weed control and crop growth. Consult your local agriculture office for more information on this method. Care must be taken to avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur.

Diseases

Damping-off and Root Rots

Damping-off occurs in seedlings which may topple over and die because of decay at the soil line. Surviving seedlings may be stunted because of a brownish rot on the roots and shoot. Pink root is a type of root rot which results in reduced bulb size. Affected plants turn yellow and wither and roots have a pink color which eventually turns brown to black.

Control: Treat seed with thiram for damping-off. To control pink root, practice a rotation of several years.

Botrytis Leaf Blight, Downy Mildew, Purple Blotch - (fungi)

Characteristics: Botrytis leaf blight develops as white spots 1-5 mm in length with light green to silvery halos. The centers of the spots become sunken

and straw colored. When spots become numerous, the leaf tips die back down the entire length of the leaf.

Downy mildew first appears on leaves as elongated patches varying in size and slightly paler than the rest of the foliage. Under moist conditions, these areas become covered with a violet gray down, which may spread to surrounding tissue. Leaves fold over at the affected areas and the leaf tips wither.

Purple blotch appears on leaves as brown spots 1-3 cm in length with red-purple margins. The brown areas may have alternating dark and light zones giving a target board effect. Leaves weakened by purple blotch may fall over. Purple blotch frequently develops after Botrytis leaf blight or downy mildew has appeared.

Control: A regular spray schedule throughout the summer is necessary to control Botrytis leaf blight and downy mildew. Practice a 2 year rotation and destroy infected crop debris after harvest and destroy refuse heaps of onions culled from storage.

Botrytis Neck Rot and Smudge (fungi), Bacterial Soft Rot

Characteristics: These rots occur during storage. Infection occurs at harvest time through the neck. Immature onions are more susceptible. Spanish-type onions and white onions require more careful attention.

Control: Be certain onions are mature before harvesting. Cure and dry onions properly (see Curing Section). Store under cool, dry conditions.

Insects

Onion Maggot

Characteristics: Onion maggots overwinter in the pupal stage with adult flies emerging from the middle of May to the end of June. Adults resemble the common housefly but are slightly smaller (6 mm) and pale grey. The elongate white eggs are laid in the soil at the base of onion plants. The creamy-white larvae emerge within 1 week, and reach a length of 7 mm when full grown. From the middle of June to the end of July, the larvae enter the soil to pupate. Within a week adult flies emerge to lay eggs again. There are two generations in most provinces, or a full first and a partial second. Sometimes even a partial third generation is produced in a long mild fall.

Control: When injury is seen, or if onion maggots are known to be a problem in your area, apply a furrow drench treatment. Established onions are not generally damaged by maggots.

Onion Thrips

Characteristics: Onion thrips are minute insects that puncture the leaves or stems and suck up the exuding sap. This causes the appearance of whitish blotches on the leaves. The insects may be found in greatest numbers between the leaf sheaths. Thrips are slender, yellow, active insects, at most 1 mm long.

Control: Treat when damage becomes visible. After the crop is harvested, the tops should be raked together and burned.

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Harvesting and Handling

Sprout Inhibition — Apply a sprout inhibitor when about 50% of the tops are down and 5 to 7 leaves are still green. Allow 10 to 20 days before harvesting. Do not apply MH-30 after the plant has dried down to 3 partially green leaves. Follow manufacturers direction.

Storage and Conditioning

Curing — Undercut or pull and windrow onions when at least 50 - 60% of tops are down, and leave in windrow until inside neck tissues are dry before topping and storing. If season is too damp for field curing, dry in storage at temperatures between 24 to 27°C with relative humidity at 70 - 80% for 2 weeks.

Onions grown from seed in Atlantic Canada will generally require artificial drying. Spanish type from transplants have been cured successfully in dry greenhouses without additional heat. Tobacco kilns have also been used.

Onions for sets are pulled and cured in late summer or early fall while the tops are still green, when the bulbs reach 2 cm in diameter. Larger sets produce a high proportion of "bolters".

Following the curing period reduce temperatures gradually with forced air ventilation to as near 0°C as possible and 60 to 70% relative humidity over a period of 4 to 8 weeks. Too rapid cooling followed by a sudden warm period may break dormancy and cause onions to sprout and increases chances of decay.

With forced air circulation, it may be possible to allow humidities as high as 85%. Root growth and decay are stimulated at higher humidities, sprouting occurs at higher temperatures. Thick-necked onions will not keep and should be removed before storing if possible. Onions are frequently stored in bins, two or four meters deep, constructed so that the bulbs can be cured by forcing air up through them. This method is considered more efficient and economical than curing and storing crates.

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Peas

Introduction

The pea is a member of the Leguminosae (pea or legume family). *Pisum sativum* originated somewhere in the Eastern Mediterranean region and Near East. In Switzerland seeds have been found dating back to about 7000 BC. This crop was grown by the Greeks and Romans. In England it was an important crop in the 11th century. During the course of cultivation some became grown as a vegetable and some for seed and fodder. More recently edible podded types have evolved. Peas are viny annual herbs being either determinate (bush type) on indeterminate (climbing type).

Minimum germination occurs at soil temperatures in the 4° - 6°C range, optimum germination occurs at 16°C to 18°C. High soil temperatures lead to poor emergence. The best growth occurs when air temperatures are in the 15° to 18°C range. High summer temperatures at flowering time are detrimental and cause yield reduction. It is, therefore, important to plant early so that maturity is reached prior to high summer temperatures. Pea maturity is closely related to the number of growing degree days above 5°C accumulated from planting time. Cultivar differences range between 1200 to 1800 degree days. Before bloom, the crop can withstand some frost but the flowers and pods are susceptible to freezing conditions. A regular water supply promotes high yields but excessive rainfall induces root rot.

Peas require fertile and well drained soil. Sandy loams and loams well supplied with organic matter are best suited. Fields with excessive slopes should be avoided since peas do not offer much protection against soil erosion.

Pea seeding occurs from early April to late May. Harvesting for early and processing markets begins in early July. Yields vary between 2200 and 5500 kg per hectare, on a shelled basis and 4400 to 8800 kg per hectare on an unshelled basis.

Presently peas are grown for processing markets and for roadside markets. Markets are potentially available for production of whole podded peas for wholesale markets and in the area of specialty crops like edible podded peas. These markets are limited due to the requirement for handpicking though the market demand is high.

Nutrient Content: Excellent source of thiamine; good sources of Vitamin A and C, and folate, plus several minerals including iron, calcium and potassium. A 250 mL (1 cup) serving provides 121 kilocalories.

Crop Establishment

Seed Treatment — innoculate the seed with a commercial Rhizobium culture where no application of bacteria has been made to the field in the past or where the nitrogen application is low.

Seeding/Planting — Seed as early as possible. Seedlings are frost resistant. The market season can be extended by a succession of seedings of one cultivar, or by seeding early, mid-season, and late cultivars at about the same time. The latter method is better since early cultivars do not yield well when sown late. Processing companies schedule seeding on the basis of heat units.

Depending on the moisture, seed peas from 1 to 4 cm deep. Largest yields result from rows sown 17 cm apart and 5 cm apart within the row. This may be less convenient in market garden crops. Such spacings require 250 to 300 kg per hectare, depending on the seed size and percentage of germination. Light rolling firms soil around the seed and encourages quick uniform germination. For mechanical harvest it presses stones into the soil and levels the surface in preparation for herbicide applications.

Crop Management

Irrigation — may be practical on this crop and significant yield increases may result from timely application. Field selection is critical in this crop as disease control by rotation must be accomplished. Choosing suitably drained fertile fields is also essential. Heavy rolling or packing is likely to reduce fertilizer uptake and pea root nodulation, and to increase the number of plants affected by root rot.

Nutrition

ALL ADDITIONS OF LIME AND FERTILIZER OR MANURES SHOULD BE BASED ON RECOMMENDATIONS FROM A SOIL TEST. WHEN TEST RESULTS ARE NOT AVAILABLE THE GENERAL REQUIREMENTS FROM TABLE 1 — 4 OF THE SOIL AND WATER MANAGEMENT SECTION OF THIS GUIDE MAY BE FOLLOWED.

Peas are generally considered to be a low fertility crop which do well on a fertile soil. Peas which re-

ceive granular fertilizers tend to remain in the fancy grades longer than in those crops that are poorly fertilized. Moderate amounts of manure may be applied to this crop.

Lime — Lime should be applied to maintain the soil pH in the range 6.0 to 6.5.

Nitrogen — sufficient nitrogen keeps peas immature and results in peas remaining in fancy grades longer than on poorly fertilized soils. Low rates of nitrogen are required. When no phosphorus and potash is recommended then nitrogen also may be omitted.

Phosphorus — usually some phosphorus is required in relatively small amounts.

Potash — This can be applied before planting and disked into the soil. Otherwise it must be banded far enough from the seed so that fertilizer burn does not occur.

Calcium — limestone banded with the seed on low pH soils may be applied at 330 to 440 kg per hectare to potentially increase yields.

Sulfur — on soils low in organic matter and heavily cropped consider the application of gypsum.

Fertilizer Application — Either broadcast fertilizer and seed separately to avoid burning the seed or band 5 cm below and 5 cm to the side of the seeded row.

Pests and Pest Control

Weeds

There are several effective preplant incorporated, preemergence and postemergence herbicides available for use on peas. Preemergence treatments provide good control of annual broadleaf weeds. When a heavy annual grass infestation is anticipated a preplant incorporated treatment should also be used. Postemergence treatments are available for both grass and broadleaved weed control. The timing of postemergence treatment is critical for the control of some species and control may be poor if applications are not properly timed.

Diseases

Damping-off (fungi)

Characteristics: Damping-off occurs in seedlings which may topple over and die because of decay at the soil line. Surviving seedlings may be stunted because of a rot on the roots. Damping-off tends to be more severe when soil moisture is high and soil temperatures are in the range of 18-24°C.

Control: Control is improved by planting seeds of high vigor.

Root Rot (fungi)

Characteristics: The taproot shows various surface discolorations of reddish brown or dark brown and smaller roots may be rotted away.

Control: Root Rot is caused by a complex of several soil borne organisms. It is present in every soil and nearly all plants have some degree of root rot. In seriously infected fields long rotations of 6 years or more are necessary. Pea refuse should always be placed in areas where peas will not be grown. Any pea refuse left on the field should be turned under deeply by fall plowing. Plant only on well drained, well fertilized soils. No resistant cultivars are available and there are no feasible chemical controls. An adequate supply of nutrients and moisture may enable infected plants to stay alive and produce an acceptable, though reduced crop.

Botrytis Rot or Gray Mold (fungus)

Characteristics: This fungus may cause severe defoliation of the lower leaves and rotting of the stems in wet seasons. Infected leaves appear fuzzy and shrivel as the infection progresses. Tips of young pods are attacked which develop small tan water-soaked lesions. These spots expand and destroy the entire pod.

Control: Plant on well drained soils. Plow down refuse immediately following harvest.

Sclerotinia Rot (fungus)

Characteristics: Watery lesions develop on any plant parts that are not exposed to air circulation. A fluffy white growth develops and affected areas become slimy.

Control: Plant on well drained soil not recently used for beans, lettuce, tomatoes, carrots, parsnips, cucumbers, celery, or cabbage. Practice a 3-year rotation. Serious losses result when susceptible crops are grown for several consecutive years. Do not apply excess irrigation. Cultivate and pick when plants are dry. Avoid fields with a history of Sclerotinia. Plow plant refuse down immediately after harvest.

Pod Spot and Ascochyta Blight (fungi)

Characteristics: Symptoms develop on stem, roots, leaves and pods. Black to purplish streaks on stems reaching from the root zone to about 25cm up the stem. Leaf spots are gray-purplish. Pod spots are gray-purplish and are sunken.

Control: Use disease free seed. In the absence of disease free seed, severely infected seed should be held over. The level of infestation drops to one-third of its original level when seed is held over for one year. Pea refuse should be disked and plowed under immediately after harvest.

Mosaic and Streak (viruses)

Characteristics: Virus diseases are transmitted by aphids. Symptoms include mishapen, discolored leaves, stems and pods.

Control: Use disease free seed. Resistance is bred into many cultivars.

Insects

Seed Corn Maggot

Characteristics: The larvae (maggot) of the seed corn maggot is 5mm long and pale in color. The damage is caused by the maggot burrowing into the seed, often destroying the germ. Damaged seed will

either not germinate or produce a deformed plant. One generation may be as short as three weeks. The adult seed corn maggot fly deposits her eggs in soil where there is an abundance of decaying vegetable matter, on the seed or plantlet.

Control: Plant as shallow as needed in a well prepared seedbed. Early germination is necessary to get good plant stands and prevent injury. Later planted crops are not as susceptible to this pest. Good weather conditions are necessary to completely control the pest. Avoid planting susceptible crops in fields very recently manured. Chemical seed treatment is essential.

Pea Moth

Characteristics: The small brown Pea Moth emerges about the time the peas are in bloom. Eggs are laid singly on the pods and plant parts. The tiny larva enters the pod after hatching. The larva feeds on the developing peas inside undectable from the outside. The fully grown larvae overwinters in a silken cocoon. They are not usually a problem in commercial fields.

Control: Early planting of peas will avoid the egg laying. Materials may be applied at first bloom.

Aphids

Characteristics: Aphids are small, soft-bodied, slow-moving insects. They are often found in large colonies on the undersurface of leaves. A colony consists of winged and wingless adults and various sizes of nymphs. Aphids may be black, yellow or pink, but mostly are various shades of green. Aphids feed by sucking plant sap. Saliva injected while feeding may carry plant viruses or may be toxic to the host plant. Feeding by large numbers discolors foliage, curls leaves and damages developing buds. The plants may be covered by a sticky substance, honey dew, which is excreted by the aphids.

Control: The Five-Spotted Lady Beetle and the Seven-Spotted Lady Beetle are helpful predators of aphids. Apply an insecticide only when aphid population is high.

SPECIFIC CHEMICAL CONTROLS FOR THE VARIOUS CROP PESTS DISCUSSED MAY BE FOUND IN THE SUPPLEMENT TO THIS GUIDE, A.P.A.S.C.C. PUBLICATION 1400A, "A GUIDE TO CULTIVAR SELECTION AND CHEMICAL PEST CONTROL FOR VEGETABLE CROPS."

Harvesting and Handling

Processing Peas: Approximately three weeks following full bloom, peas are ready for harvest. Quality of peas deteriorate with maturity. Hot dry weather during harvest speeds up maturity without corresponding increases in yield. Soils adequately supplied with nitrogen and/or organic matter result in increases in yield and mature less rapidly than those lacking sufficient amounts of these nutrients. For this reason peas produced on fertile soils remain at peak quality for a longer period, thus providing a greater opportunity for orderly harvest of peas.

Green peas: The pods are harvested when they are well filled, but still succulent, before they harden and fade in color. The peas should not be hard and starchy. Peas are best picked and shelled just before cooking as the sugar content decreases rapidly after harvest. Two or three pickings are made as all the pea pods do not mature at the same time. The pods should be carefully pulled from the vine to prevent the plants from being uprooted. At the last harvest, the plant may be pulled up and all the pods picked.

Edible Podded Peas: These peas are picked when the pods are long and the peas just developing. Pods, three to five inches long, are produced five to seven days after flowering, and the pea seeds are slim and small. Pods need to be picked every other day to prevent them from developing large seeds and fibrous pods. If the seeds develop, they may be used similar to English peas.

Storage and Conditioning

Unshelled peas can be held a week or two if cooled to 0°C immediately after harvest, and held at 0°C with a relative humidity of 95%.

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Peppers

Introduction

Peppers are a member of the Solanaceae (night shade family). *Capsicum annuum* is a native of the tropics and is related to many crop plants such as potatoes, tomatoes and eggplant. Peppers may be "hot" or "sweet". The fruit size varies from 1 to 30 cm in length, from thin to thick fleshed, conical to blocky or flattened, both yellow and green, at an immature stage, and with, red, yellow and brown mature fruits. This plant is a perennial in warm climates but grows as an annual in northern climates.

It is thought that all species of capsicum are of American origin. The centers of origin appear to be Mexico and/or Central America. When America was discovered peppers became adopted immediately and their use became worldwide.

Peppers are a long season, heat loving crop. This crop requires 3 1/2 to 4 months of frost free weather for good yields. They are very sensitive to frost and cold weather so are not generally transplanted until mid June. The minimum soil temperature for seed germination is 15°C with a maximum of 35°C and an optimum range of 18 to 35°C. Best growth and quality occurs at an optimum range of 21 to 24°C with a minimum of 18°C and a maximum of 26°C. Fruit set for many cultivars fail when temperatures drop below 13 to 18°C. At temperatures above 32°C blossom drop becomes excessive. Large fruited cultivars tend to drop many of the flowers that form after several fruit have started to develop on the plant. Flowering will resume if these fruit are harvested and soil and weather conditions are favourable.

Only with the development of cultivars such as "Ace Hybrid" and "Super Set", has pepper growing in the field become a possibility. Peppers are mainly limited to the areas which can successfully grow grain corn.

Peppers require an adequate and regular supply of water. Well drained soils, well supplied with organic matter are required. Sandy loams and loams are optimal. Sheltered fields with natural or artifical windbreaks are necessary.

High production is possible in unheated tunnel houses. Early cultivars may have some fruit by the 1st week in July and production can carry on until late October. Red peppers do not mature on cultivars such as "Super Set" until late August. In the field crops are highly variable in yield from year to year. 6000 kg per hectare is thought to be a good field yield. In tunnel houses yields of 4.5 kg per square meter have been obtained (45,000 kg per hectare).

No sizable area of this crop is grown in the Atlantic Area. Tunnel houses are starting to show some promise for direct marketers. Due to the high capital costs of tunnels and the fluxuating wholesale prices of peppers it is not known whether wholesale markets could be economically developed. Specialty peppers such as yellow, hot, red, etc. may be grown for retail chain stores or the H.R.I. Trade.

Nutrient Content: Excellent source of Vitamin C. Good source of other vitamins and minerals including potassium. Low in calories — one medium raw pepper contains about 15 kilocalories.

Crop Establishment

Seed Treatment — seed may be pelleted for mechanized greenhouse seeding (for transplant propogation).

Seeding/Planting — Peppers germinate and grow slowly so seed should be sown 9 to 10 weeks before field transplanting. Peppers must be started in a greenhouse or hot bed. The seed is sown in shallow flats of soil or soilless mix. A temperature of 27 to 29°C is required for good seed germination and steady plant growth. Approximately 200 g of seed is enough to produce 25,000 plants.

When the first leaves are about 1.5 cm long, transplant the seedlings to other flats containing a fertile compost soil. Space the plants 5 to 7 cm apart. Where space is available, transplanting to 8 to 10 cm plant container will produce larger plants with compact, well-developed root systems. These plants suffer less from transplanting shock.

Alternatively, plants can be raised by seeding raw or pregerminated seed directly into peat pots, multipot trays, wedge-shaped plant modules or directly into beds. Such systems are less labor intensive, results in superior plant material raised in shorter time and reduces transplanting shock.

Pepper plants are hardened for about one week before transplanting to the field by reducing the soil moisture supply and maintaining a temperature of 13 to 16°C. Hardening of pepper plants gives resistance to wilting, but not to frost.

The number of flowers and fruits on the plants can be increased by exposing the seedlings to a controlled cold treatment, as follows:

1. Germinate seed at 27 to 29°C in flats of sterilized soil or whatever sterile medium is used for growing young seedlings.

2. When the third true leaf of the seedlings appears, grow the plants at a minimum night temperature range of 12 to 13°C for 4 weeks. The plants can receive the cold treatment either before or after the first transplanting. The plants should receive as much sunlight as possible.

3. After 4 weeks of cold treatment, grow the plants at the recommended temperature of 21°C.

Transplant to the field only when the soil has warmed and the danger of frost is past (early to mid-June). In tunnel houses depending on supplemental heat, from early May to early June.

Space rows 60 to 75 cm apart, depending on equipment to be used. Space plants 40 to 45 cm in the row, approximately 25,000 plants per hectare required (more for tunnel houses).

Crop Management

Black plastic mulch is effective for pepper production in controlling weeds around the plant and is often beneficial in obtaining higher early yields. Clear plastic mulches are more effective at warming the soil and promoting better growth but weeds under the plastic must be controlled with a herbicide.

Poor setting of fruit is usually the principal cause of low yields. Low night temperature (below 13 to 18°C) or extremely hot temperatures (in row tunnels or tunnel houses) are the principal causes of poor blossom set. Tarnished plant bugs also injure pepper flowers causing them to drop.

Nutrition

ALL ADDITION OF LIME AND FERTILIZER OR MANURES SHOULD BE BASED ON RECOMMENDATIONS FROM A SOIL TEST. WHEN TEST RESULTS ARE NOT AVAILABLE THE GENERAL REQUIREMENTS FROM TABLES 1 – 4 OF THE SOIL AND WATER MANAGEMENT SECTION OF THIS GUIDE MAY BE FOLLOWED.

Peppers respond to a good fertilization program with a continuous supply of plant nutrients but not a highly fertile soil.

Manure – may be applied and fertilizer rates adjusted.

Lime – may be applied to maintain the soil pH in the range 6.0 to 6.8.

Nitrogen – nitrogen is usually partly broadcast preplant along with the needed phosphorus. If manures are applied then the nitrogen level should be reduced. After some fruit is set, nitrogen should be sidedressed. Foliar sprays of urea may also be used.

Phosphorus – A starter solution high in phosphorus should be used at the time of transplanting. Band the phosphorus if mechanically possible. Use fields high in phosphorus.

Potash – peppers do not have a high requirement for potash. It would be best to broadcast and incorporate, before planting if needed.

Magnesium – a deficiency may occur if soil levels are low. Apply dolomitic lime prior to planting or apply folair applications of magnesium sulphate (Epsom Salts).

Sulfur – apply gypsum if a deficiency is anticipated. This usually occurs on sandy soils low in organic matter where manures are not used.

Micronutrients

Boron is not generally recommended unless soil levels are low. Foliar spray(s) may be applied, if necessary.

Application method – At transplanting apply a starter solution high in phosphorus. Under high temperature conditions or in dry sandy soils reduce the amount of fertilizer by one half but use the same volume of water. This will reduce the risk of crop injury under these growing conditions. Broadcast some of the nitrogen and all of the phosphorus and potash before planting and work into the soil. If possible nitrogen should be sidedressed. Banding of large amounts of nitrogen and potash may injure this crop. In tunnel houses fertilizer may be fed through trickle irrigation systems.

Pests and Pest Control

Weeds

Perennial weeds must be controlled before planting. In the field preplant incorporated herbicides may be applied to effectively control annual grasses and some broadleaved weeds. There are only a few available herbicides which provide fair weed control for use on peppers after transplanting and preemergence to annual weeds. These materials control annual grasses but only a small spectrum of annual broadleaf weeds. Cultivating and hoeing are necessary to control weed escapes from herbicide treatments. Black plastic mulch can be used in the field and tunnel houses to control weeds. Care must be taken to avoid fields where residual herbicides from the previous year persist in the soil, as crop injury may occur.

Diseases

Damping off (fungi)

Characteristics: Seed may decay, fail to emerge or once emerged develop water soaked discolored areas on the stems which withers and causes the plant to fall over. Disease incidence and severity is increased by cold temperatures, over watering, high humidity and over crowding.

Control: Apply a fungicide seed protectant. Plant seeds at recommended rate into sterilized seeding mix and flats. Supply adequate moisture but do not over water, and maintain night temperatures above

16°C. Drench immediately after planting with a fungicide. If damping-off occurs continue to apply fungicides at weekly intervals.

Verticillum Wilt (fungus)

Characteristics: Caused by a soil-borne organism that can survive in the soil for many years. Lower leaves yellow and wither, eventually whole plant may wilt and die.
Control: Grow seedlings in sterilized soil. Treat seed with fungicide. Avoid fields recently planted to tomato, potato or strawberry (a four year rotation). Do not plant before soil temperature has reached 16°C. Use resistant cultivars.

Bacterial Spot (bacterium)

Characteristics: Caused by a bacterium this disease affects both leaves and fruit. Leaf spots are up to 0.5 cm, gray-brown and often drop out causing leaves to look ragged. Fruit spots are raised and scab like. The disease is carried on the seed and spreads rapidly with continued wet weather.
Control: Sow hot water treated seed. Grow seedlings in sterilized soil and flats. On the first appearance of the disease, make several applications of fixed copper at label rates. Infected plants should not be set in the field. Follow at least a two year rotation and do not follow tomatoes.

Viruses

Peppers are susceptible to the same viruses which infect tomato. See control recommendation under that crop.

Insects

Cutworm

Characteristics: Cutworms are dull colored, soft-bodied caterpillars found at the base of plants, just under soil level. They feed on seedlings, cutting them off at soil level or just below.
Control: See Appendix III of the supplement.

Aphids

Characteristics: Aphids are small, soft-bodied, slow-moving insects. They are often found in large colonies on the undersurface of leaves. A colony consists of winged and wingless adults and various sizes of nymphs. Aphids may be black, yellow or pink, but mostly are various shades of green. Aphids feed by sucking plant sap. Saliva injected while feeding may carry plant viruses or may be toxic to the host plant. Feeding by large numbers discolors foliage, curls leaves, and damages developing buds. The plants may be covered by a sticky substance, honey dew, which is excreted by the aphids.
Control: Use insecticides as needed.

Tarnished Plant Bug

Characteristics: Small 6 mm long insect, mottled white and yellow with touch of black on wings. Nymph is very small, greenish-yellow and marked with black dots on the thorax and abdomen. They overwinter under bark or leaf-litter, emerging early in the spring and feeding on weeds and fruit buds. After mating, eggs are laid of stems and petioles. Nymphs (yellowish-green, 1 mm long) emerge after 10 days, undergoing two molts to become adults within 3-4 weeks. Adults and nymphs are equally damaging; blossoms that have been injured drop, reducing fruit set.

Control: Apply insecticides when insects first appear. Repeat as necessary.

European Corn Borer

Characteristics: The European corn borer is a flesh colored caterpillar, 2.5 cm long with brown spots and a dark brown head. They are a problem in some areas, boring into the fruit of the pepper plant.

Control: Avoid planting near last year's crop field.

Non-parasitic Disorders

Blossom-end Rot

Characteristics: A physiological disorder. Lack of adequate soil moisture (or the inability of the plant to take up water) and insufficient calcium uptake from the soil to the fruits during dry weather have been shown to cause this disorder. Excessive magnesium, potassium, sodium, or ammonium salts, or a deficiency or soluble calcium salts, all tend to decrease calcium uptake. Rapid early growth adds to the problem because it increases the need for calcium.

Control: Timely irrigation will reduce or prevent this disorder. If drought occurs and irrigation is not possible, cultivation should be very shallow to reduce water loss. Maintain high organic matter content in the soil and a high soil pH. A spray application of calcium chloride, or a trial preplant application of gypsum, may be useful if other control measures have not been successful.

SPECIFIC CHEMICAL CONTROLS FOR THE VARIOUS CROP PESTS DISCUSSED MAY BE FOUND IN THE SUPPLEMENT TO THIS GUIDE, A.P.A.S.C.C. PUBLICATION 1400A, "A GUIDE TO CULTIVAR SELECTION AND CHEMICAL PEST CONTROL FOR VEGETABLE CROPS."

Harvesting and Handling

Sweet peppers are usually harvested as green fruit, but if left on the plant to ripen usually become red, while some cultivars are yellow when ripe. For best yield and quality, green peppers are harvested when they reach full size, are firm, and have thick flesh. This is shortly before they begin to change color. Hot peppers are usually picked after they have changed color.

Storage and Conditioning

Peppers may be held about two weeks if quickly cooled with forced air to 7 to 10°C and retained at 8 - 9°C. A high humidity of 95-98% is optimal. Packaging in polyethylene, sufficiently ventilated to prevent condensation is preferable to waxing. Some ripening occurs at 10 degrees C.

Chilling injury occurs at lower temperatures. It requires about 2 days of 0°C, 7 days at 1°C, 14 days at 7°C to cause injury.

The main symptom is surface pitting; that is, numerous shallow roundish depressions distributed over most of the green pepper fruit surface. Symptoms do not appear until several days at high temperature after chilling, and are less in high humidity. Alternaria rot generally develops on injured tissue.

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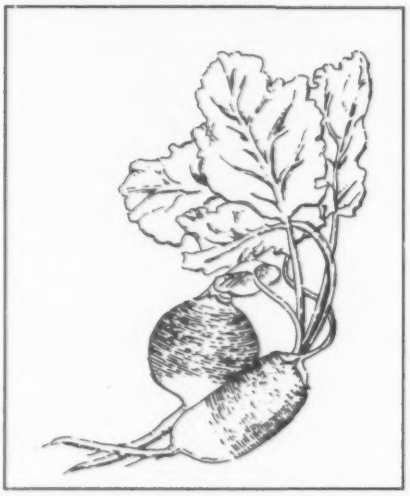
Radish



Introduction

Radish is a member of the Cruciferae (mustard family). *Raphanus sativus* is a cool season annual (depending on when it is planted). Radishes have been cultivated for thousands of years in both China and the Mediterranean area. Radishes were a common food in Egypt before the building of the pyramids and is one of our most ancient cultivated plants. Generally commercial radishes are approximately 2 cm in diameter and are either red or white. They reach market size in 21 to 28 days (or longer in cool weather). There is also a radish group called *daikon* (Longipinnatus group) which is the Chinese oriental radish. These may grow up to 75 cm long with a diameter of up to 25 cm. These may weigh several kilograms. Radish vary in color from white to black.

Radish is a quick growing cool season root vegetable. The seed will germinate in 3 to 4 days with soil temperatures of 18 to 30°C with good moisture. The minimum temperature for germination is 5°C, the optimum temperature for germination is 30°C. The maximum temperature for germination is 35°C. Germination rates decline sharply when the soil temperature falls below 13°C. The best quality and root shape are obtained when the crop grows and matures at moderate temperatures (10 to 18°C) in intermediate to short day lengths. Roots of globe varieties tend to elongate and develop poor shape in hot weather when the tops also grow taller and larger than in cool weather. Long days induce flowering or seed stalks (bolting) and with warm weather the seed stalk may develop so rapidly that no edible root is formed. Radishes become more pungent in hot weather. Roots remain in marketable condition only a short time before becoming pithy. Growth must be continuous and rapid for good quality. This crop also requires an even moisture supply for good quality.

This crop requires a well drained sandy loam or loam with a good supply or organic matter. Rocky or gravelly soils are generally not acceptable especially if bed harvest is to be used. Peat soils are also suitable for production of radish.

Regular radish reach market size in 21 to 28 days so crop can be on the market from June to the end of October. Chinese radish take 50 to 90 days to mature. These become available to market in August and with storage can be marketed into November and December. Yields per hectare depend on the variety and the number of crops per year. Regular radish yield 10,000 to 15,000 kg per hectare. Chinese Radish may yield 30,000 to 44,000 kg per hectare.

Currently radish is a minor crop and markets are quite limited, but there is room for a few growers to supply regular radish, wholesale (bunching and cello pack), and specialty markets with chinese radish.

Nutrient Content: Good source of Vitamin C, potassium and magnesium, plus trace amounts of other nutrients. Four radishes supplies 5 kilocalories.

Crop Establishment

Seed Treatment — accurate spacing is obtained from sized seeds and precision seeders.

Seeding/Planting Seedings at 10 day intervals from early spring will provide a continuous supply. Seed at 11 to 17 kg per hectare, and up to 20 to 34 kg per hectare for machine harvesting. Seed depth should be 0.5 to 1 cm. Planting deeper then 2 cm produces elongated roots. Space rows 20 to 30 cm apart, or as determined by equipment. Plant stands should be 40 to 50 per meter of row. For machine harvest space rows 10-15 cm apart.

Crop Management

Spring Crop — The seed may be sown in the spring as soon as the soil is workable. Spring frosts, or even heavy snowfalls, after the plants have emerged, usually do not injure the crop seriously. Under favorable weather conditions radish seedlings appear above the ground two or three days after sowing. Sowing at intervals during the spring will provide a continuous harvest.

Summer and Fall Crops — Crops must be well supplied with moisture by irrigation. Some crop loss may occur where temperatures are too high and bolting occurs. Seeding may continue up to early September. Tunnel houses may be used to extend the season both early in the spring and late in the fall.

Nutrition

ADDITIONS OF LIME AND FERTILIZER OR MANURES SHOULD BE BASED ON RECOMMENDATIONS FROM A SOIL TEST. WHEN TEST RESULTS ARE NOT AVAILABLE THE GENERAL REQUIREMENTS FROM TABLES 1 - 4 OF THE SOIL AND WATER

MANGEMENT SECTION OF THIS GUIDE MAY BE FOLLOWED.

Radish require a fertile soil but only moderate amounts of fertility.

Manures — are not generally recommended due to weed seed problems and their unpredictable release of nitrogen for such a short season crop.

Lime — Lime should be applied to maintain the soil pH at 7.0.

Nitrogen — A relatively low amount of nitrogen is usually broadcast preplant and incorporated into the soil.

Phosphorus — would be best banded but is usually broadcast prior to planting and incorporated in the soil.

Potash — is usually broadcast before seeding but up to 70 kg per hectare could be banded.

Sulfur — on sandy soils with low organic matter that are intensively cropped an application of gypsum should be considered.

Micronutrients — Apply .2% *boron* in the fertilizer. A foliar spray of boron should be considered on sandy soils high in pH.

Application method — banding of the fertilizer 5 cm below and 5 cm to the side would be ideal for this crop. Rates of fertilizer could be substantially lowered if this practice could be carried out.

Pests and Pest Control

Weeds

No herbicides are registered for use on radish. Cultural control methods including crop rotation, stale seedbed, fallowing, cultivation and handweeding must be used.

Care must be taken to avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur.

Diseases

Clubroot (fungus)

Characteristics: The fungus causing clubroot in rutabagas and cole crops is usually present in areas where these crops have been grown for many years. Land will remain infested for 7 years or longer after a diseased crop. Certain weeds of the mustard family, such as wild radish and wild mustard (cadlock) will maintain or increase the level of infestation year after year. Every effort should be made to control weeds of this family.

Control: Avoid problem soils. Adjust pH levels to 7 before planting. See the section on Cole Crops in this Guide for more specific information.

Other Diseases

Radish is subject to many of the diseases affecting cole crops. Refer to Cole Crop and Rutabaga sections for information on black rot, black leg, downy mildew, scab and bacterial soft rot.

Insects

Root Maggot

Characteristics: The adult is a grey fly, half the size of a housefly, which lays white eggs at the base of plants. Legless white maggots, which hatch out of the eggs, tunnel into roots causing rotting of the roots and wilting of the plant.

Control: Apply a soil insecticide at planting.

Flea Beetles

Characteristics: Flea beetle adults are 1.5 to 3 mm long, black or bronze beetles. Their hind legs are well developed for jumping. The white larvae are in the soil, and therefore seldom seen. Depending on species, there are one or two generations a year. Adults overwinter in the soil. Eggs are laid on or near the roots where larvae feed. Mature larvae pupate in the soil near the host plant. Adults emerge in early August for single-generation species. Last-generation adults feed on foliage until fall, when they return to the soil to overwinter.

Control: Heavy damage can occur quickly, so prompt attention is necessary when an infestation is noticed.

Aphids

Characteristics: Aphids are small, soft-bodied, slow-moving insects. They are often found in large colonies on the undersurface of leaves. A colony consists of winged and wingless adults and various sizes of nymphs. Aphids may be black, yellow or pink, but mostly are various shades of green. Aphids feed by sucking plant sap. Saliva injected while feeding may carry plant viruses or may be toxic to the host plant. Feeding by large numbers discolors foliage, curls leaves, and damages developing buds. The plants may be covered by a sticky substance, honey dew, which is excreted by the aphids.

Control: Apply recommended materials when aphids are numerous.

SPECIFIC CHEMICAL CONTROLS FOR THE VARIOUS CROP PESTS DISCUSSED MAY BE FOUND IN THE SUPPLEMENT TO THIS GUIDE, A.P.A.S. C.C. PUBLICATION 1400A, "A GUIDE TO CULTIVAR SELECTION AND CHEMICAL PEST CONTROL FOR VEGETABLE CROPS."

Harvesting and Handling

Harvesting operations consist of pulling, topping, washing, grading, bunching, and packing. All small, diseased, and cracked roots are discarded. Bunching is frequently done in the field but the practice is seldom practiced except for local market. Long-rooted cultivars are bunched in fours and fives, while round and globular-rooted cultivars are tied in bunches of 6 to 12. Baskets, hampers, and crates are the principal containers. For long-distance shipment, cracked ice is placed in the middle and top of the containers, and the radishes are shipped under refrigeration.

Storage and Conditioning

The recommended storage temperature is 0°C with a relative humidity of 95 to 100%. Radishes will keep well for 2 weeks under ideal conditions.

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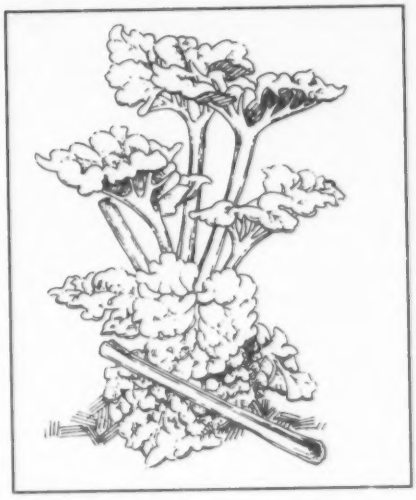
Rhubarb



Introduction

Rhubarb is a member of the Polygonaceae (the buckwheat family). *Rheum rhaponticum* is a herbaceous perennial, the underground portion consists of fleshy and woody rhizomes and a fiberous root system. The petioles (stems) of the leaves are used for food. Botanically rhubarb is a vegetable but in its domestic use it is considered to be a fruit. It is a native of Central Asia. It was first grown for its root which was used for medicinal purposes (approximately 5000 years ago in China). It was being grown in Europe in the 1700's but not until 1778 was it definitely recorded as a food plant. By 1820 a method of forcing in the dark had been developed. Rhubarb plantings can remain productive for up to 5 years.

Rhubarb crown and rhizomes are resistant to cold and dry conditions. A dormant period does not seem to be essential since the crop will grow continuously under irrigation in California. The vegetative parts of the plant are killed at -3°C. At relatively low temperatures the stalks develop pink color while at higher temperatures green coloration is more prominent. It thrives best in regions having cool moist summers and winters cold enough to freeze the ground to a depth of several inches. Forcing of Rhubarb cannot occur until dormancy is broken. Dormancy is broken by exposing crowns to a period of low temperatures. The duration of the low temperature depends on the cultivar. Gibberellic Acid may be used to substitute for part of the "cold units". Cold units are calculated on a 10°C basis taken at a 10 cm depth at 9am beginning on October 1st. All degrees below 10°C are noted each day to come up with an accumulated cold unit figure.

Rhubarb requires deep well drained sandy loam to loam soil with a good supply of organic matter. Heavy soils are satisfactory if they are well drained but the structure should be improved with manure or other forms of organic matter. Early field production requires light soils with a southerly exposure and a well sheltered field.

This vegetable crop is either field grown or forced inside sheds. Forced rhubarb is produced for the winter fresh market, field rhubarb is produced for the spring, early summer fresh markets, and the processing market. Field yields depend on the vigor and age of the stand and range between 15,000 and 40,000 kg per hectare. Forced yields would be 15,000 - 20,000 kg per hectare of field root. (2kg to 3 kg per root). Only the red stalked cultivars are suitable for fresh or forced rhubarb. These cultivars yield less than green stalked cultivars.

Presently rhubarb is grown in small quantities for the early fresh market and a sizable amount is grown for processing (frozen) pack. Some markets exists for the forced product if it can be produced economically. This depends on the cost of capital facilities and labor.

Nutrient Content: Contains several nutrients including Vitamins A and C, thiamin, riboflavin, niacin, potassium and phosphorus. 250 mL (1 cup) raw rhubarb contains 20 kilocalories. 125 mL (1/2 cup) sweetened, cooked rhubarb has about 150 kilocalories.

Crop Establishment

Seeding/Planting — Rhubarb is not propagated from seed since seedlings are not true to type. Divisions for starting new plantings are sometimes available commercially. However, if propogation is necessary, select vigorous, disease-free plants the summer before divisions are to be made and mark them with stakes. Dig the selected plants while they are dormant, either in the fall or early spring. Store in a cold place and protect from successive freezing and thawing, drying out and damage to buds. Close to planting time in the spring, cut each plant into as many divisions as possible — each with one or two well developed buds and as large a piece of the adjacent root material as possible. Protect divisions from drying out before and during planting. Each parent plant will produce from 4 to 20 divisions.

Rhubarb is normally planted as early as possible in the spring since growth begins when soil temperatures are still well below 10°C. Plants are spaced 1 m by 1 m apart (10,000 divisions per hectare). Set divisions deep enough to cover the root piece but leave the tip of the bud just visible at the soil surface. Planting on the square allows cultivation in two directions. In general higher plant populations result in increased yield per hectare but less yield per plant. To produce roots for forcing, spacing in the field may be adjusted to 75 cm between rows and plants (17,220 plants per hectare) without any loss of yield or quality.

Crop Management

The first growing season — Cultivation should be as shallow as possible and throughout the growing season. Hand hoeing will probably be required. Flower stalks should be cut out as soon as they appear. One or two sidedressings of nitrogen may be necessary. No crop should be harvested the first season. In the fall well rotted manure should be applied to the soil surface.

Following years — Cultivate occasionally to keep weeds in check but be careful not to cultivate too deep or close to the crown and fleshy roots. A small two week harvest period may be made the second year if the previous season's growth has been good. Stalks should not be harvested until late in the season. The stalks are pulled from the crown during harvest, they are not usually cut. Generally harvest is not for more than 8 to 10 weeks during the third and future seasons. If too many stalks are removed, the root cannot build up enough carbohydrates for next year's production and the plants will produce thin leaf stalks.

Flower stalks are removed during crop harvest for processing rhubarb. For fresh market rhubarb, flower stalks are removed when they show up in the field. This helps keep plants vigorous.

In 6 to 8 years crowns often become rather crowded and produce small stalks. It is advisable either to replant the bed or reduce the number of buds on the crown by pruning.

Forcing Rhubarb — Plants are grown in the field for two years. Forced yields depends on the size of the root used for forcing. Dig plants just before the ground freezes solidly in the late fall taking as much root as practical. For late forcing, store plants in a cold place, and protect them from successive freezing and thawing, drying out and damage to buds. Severe freezing is injurious.

Gibberellic acid is useful in rhubarb forcing to assist in breaking dormancy to permit early production. This may allow time to force two crops in the house. Gibberellic acid also tends to increase yields.

Plants are forced in darkness, in structures where temperatures can be maintained at 11 to 13°C. At higher temperatures quality is poorer and at lower ones growth is slow. An earth floor is desirable. Place plants as close as possible (approximately 10 per square meter) and fill around the roots with soil or peat, leaving tips of buds uncovered. Water well and maintain a good water supply during forcing.

Adequate ventilation is needed to reduce humidity for the control of botrytis rot. Harvest normally starts about 4 weeks after forcing begins and extends 6 to 8 weeks. Stalks are usually harvested twice a week.

For continued production new beds should be started at intervals. The roots should be discarded after termination of the crop.

Early Field production — Clear plastic row covers will advance growth by two to three weeks when applied in early April.

Nutrition

ALL ADDITIONS OF LIME AND FERTILIZER OR MANURES SHOULD BE BASED ON RECOMMENDATIONS FROM A SOIL TEST. WHEN TEST RESULTS ARE NOT AVAILABLE THE GENERAL REQUIREMENTS FROM TABLES 1 - 4 OF THE SOIL AND WATER MANAGEMENT SECTION OF THIS GUIDE MAY BE FOLLOWED.

Rhubarb grows well in a highly fertile soil high in organic matter and well drained. A green manure crop is desirable the year before planting. Also in the fall 45 tonnes of manure per hectare may be added. An annual fall application of manure is beneficial.

Lime — Lime should be applied to maintain the soil pH in the range 6.0 to 6.8 (Rhubarb will tolerate soil acidity as low as 5.0 but yields and fertilizer efficiency will suffer).

Nitrogen — Rhubarb has a high requirement for nitrogen. Apply nitrogen at bud break along with the phosphorus and potash requirements. Apply one or two sidedressings of nitrogen after harvest or on crops to be used for forcing. Applications of manure will supply part of the nitrogen requirement of this crop.

Phosphorus — is most important in the establishment year. Fields selected for rhubarb should be high in phosphorus.

Potash — is only added if soil levels are not adequate.

Magnesium and/or Sulfur — may be needed on sandy soils low in organic matter. Foliar sprays of epsom salts or the use of gypsum and dolomitic limestone may be considered.

Application method — broadcast N,P & K in the spring just before applying manure (if available). Sidedress or broadcast nitrogen or apply it through an irrigation system. Cultivation between the rows will mix some of the broadcast fertilizer into the soil and control some perennial weeds.

Pests and Pest Control

Weeds

Control weeds well before planting. Start cultivation early in the spring. Cultivation should be shallow to avoid injury to roots and can continue as late in the season as possible without damaging the plants.

Diseases

Leaf Spots — Ramularia and Ascochyta (fungi)

These fungi cause circular, or angular spots, variable in size having beige centers surrounded by a red zone. When affected tissue dies, it may drop out, leaving large ragged holes in the foliage. Fungi overwinter in infected plant debris and in infected propagation stock.

Control: Remove and destroy leaves following the first heavy frost. During harvest, remove stems with spotted leaves first. Apply fungicide used for *Botrytis* control.

Botrytis Rot (fungus)

May cause a leaf, stem and crown rot of forced rhubarb. Disease intensifies where there is poor air circulation and high humidities.
Control: Practice strict sanitation. Apply recommended fungicide at first sign of disease and at 7 day intervals.

Insects

Potato Stem Borer

Characteristics: The first stages of the insect attack only weeds, couch grass in particular.
Control: This pest is not a problem when couch grass and other weeds are controlled in and around the rhubarb plantation.

SPECIFIC CHEMICAL CONTROLS FOR THE VARIOUS CROP PESTS DISCUSSED MAY BE FOUND IN THE SUPPLEMENT TO THIS GUIDE, A.P.A.S.C.C. PUBLICATION 1400A, "A GUIDE TO CULTIVAR SELECTION AND CHEMICAL PEST CONTROL FOR VEGETABLE CROPS."

Harvesting and Handling

Rhubarb stalks should be pulled rather than cut. Do not harvest the first year. A small harvest may be made the second year if growth has been good. In the third and subsequent years, the harvest season can be extended to 8 to 10 weeks if stalks are of satisfactory size. Harvest can be longer than this if the planting is to be abandoned.

Storage and Conditioning

Store only fresh stalks in good condition. Store at a temperature of 0°C, and a relative humidity of 90 to 95%. Stalks can be held 2 to 3 weeks under these conditions. Provide ample air circulation on all sides to prevent heating.

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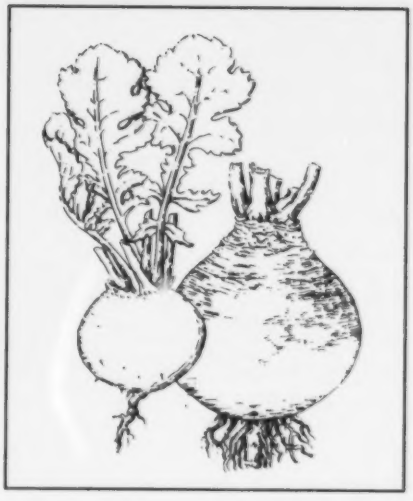
Rutabaga and Turnip



Introduction

Both turnip and rutabagas are in the cruciferae (mustard family).

Brassica rapa Rapifera group is closely related to chinese cabbage and mustards. It is usually a biennial but is cultivated as an annual. It seems to have originated in areas of Europe and Siberia. It has been cultivated since ancient times. Turnips have a white or yellow fleshed root generally of a flattened globe shaped root. The root is less dense than the rutabaga and lacks a neck. It is also free of secondary roots which occur on the tap root of a rutabaga. The leaves are hairy and without the wax of a rutabaga.

Brassica napus Napobrassica group (rutabagas) are closely related to cole crops and seem to have originated in the Mediterranean area. The rutabaga was introduced by England about the end of the 18th century and was called the turnip rooted cabbage. Both white and yellow fleshed cultivars exist. The rutabaga root consists of both true root and true stem. The upper portion of the stem forms a neck. This neck distinguishes rutabagas from turnips. Rutabaga is the french name for a "Swede" turnip.

Turnips and rutabagas are well adapted to cool and humid growing conditions. The minimum temperature for germination is 5°C, the optimum germination range is 15 to 40°C, with an optimum germination temperature of 15°C. They favour growing temperatures in the 15°C to 20°C range and are frost resistant but are not usually left in the ground later than the end of October. They can withstand dry periods if some soil moisture is available. Growth is reduced by an excess of water. Cracking of the root may occur with an excessive growth rate brought on by heavy fertilization, wide spacings and hot humid weather. Sometimes these growth cracks become infected with soft rot.

These crops thrive on moist, well drained and moderately acid, sandy loams, loams and clay loams which are well supplied with organic matter. On sandy loams roots may tend to be elongated especially in dry weather and with dense plant populations. The best quality crops seems to come from clay loam soils which are well drained and that have not been intensively cropped.

In the Atlantic area both turnips and rutabagas are grown commercially only for their roots. The turnip (white purple top) being earlier is marketed 2 weeks before the early rutabagas are available (July 1 — 14). Turnips may be grown throughout the year especially with the aid of irrigation from July 1st to the end of October. This crop may also be stored for short periods of time depending on the availability of markets. Yields of turnips could range between 25,000 to 35,000 kg per hectare. Rutabagas are marketed from mid July until the end of October from the field and are marketed from storages until the 1st of July (or later in some years). It is one of the few vegetable crops we can have on the market 12 months of the year. Rutabagas should produce marketable yields of 20,000 to 50,000 kg per hectare under good growing conditions with adequate pest control.

Turnips and rutabagas are important crops in the Atlantic area for domestic markets and for export. Maintaining and expanding markets for this crop with better quality and marketing techniques is probably the best development strategy. Small amounts of rutabagas are processed on a sporadic basis mainly for canning purposes. Specialty markets may exist for some types of turnips.

Nutrient Content: Good source of Vitamins A and C; potassium and small amount of other nutrients. Low in Sodium. 250 mL (1 cup) rutabaga raw contains 42 kilocalories; cooked - 74 kilocalories.

Crop Establishment

Seed Treatment — obtain sized, registered seed of a high percentage germination and vigor.

Seeding/planting — Rutabaga seedings for early market may be made as soon as soil can be worked. For the main storage crop, plant late in June or early in July, so that the roots will develop during the cool fall weather. Seed at the rate of 225 to 450 g per hectare and at a depth of .6 to 1.2 cm. Seed should be sown 10 to 17 cm apart in rows 50 to 90 cm apart. Use seeders that space the seeds to known intervals, or to stand. This will eliminate thinning and produce a highly uniform crop. Where thinning is required, do so when the plants are 4 to 8 cm high. Space 15 cm apart in the row. Use the wide in row spacings for early production and the close spacings for producing small product for poly bag packs. (Spacing affects both the size and the harvest date.)

Crop Management

Cultivate — Start cultivation early for weed control, cultivate shallowly and frequently.

Irrigation — may be used sometimes to cool and slow the growth of the crop as well as to promote growth and quality. Irrigation may activate soil insecticides or carry fertilizer to the plant roots.

Early crops — may be grown with the use of transplants. Transplants may be started in late March and field set or placed in tunnel houses in mid to late April. Turnips are earlier than rutabagas. There appears to be little difference in the earliness of maturity in rutabaga cultivars. These crops may be seeded in module trays or peat blocks.

Rotation — Long rotation is critical in these crops.

Nutrition

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Turnips and rutabagas require only moderate amounts of fertility. A better quality product is produced if the growth is moderate and uniform, and the crop matures under cool conditions.

Manures — Manures may be used but excessive levels coupled with wide spacings and hot humid weather have led to excessive splitting and sometimes total loss of the crop. There are high risks in trying to produce rutabagas by mid July.

Lime — Lime should be applied to maintain the soil pH in the range 6.0 to 7.0.

Nitrogen —too much can be detrimental to this crop in terms of growth cracks and the reduced storage life of the crop. Excessive nitrogen and high plant populations may also cause the rutabaga root to become elongated. Usually nitrogen is broadcast preplant and incorporated into the soil. Some early rutabaga growers may also sidedress their crop in June.

Phosphorus — is generally applied preplant and incorporated into the soil. High rates of phosphorus are thought to increase the growth rate of this crop in warm humid weather along with nitrogen resulting in more growth cracks.

Potash — These crops do not generally respond to potash. Generally potash is applied preplant incorporated.

Sulfur — On sandy soils with low organic matter that are intensively cropped without the use of manure, application of gypsum should be considered.

Magnesium — On soils low in pH, especially sandy soils, magnesium levels may be low. Apply magnesium in the fertilizer, apply dolomitic limestone and/or apply foliar sprays of magnesium sulphate (epsom salts).

Micronutrients — *Boron* deficiency causes "brown-heart" or "watercore". Apply 3 kg per hectare of boron with the fertilizer at the time of planting; also apply one or two sprays (10 days apart) of solubor at 3.5 per hectare when the roots are 1 to 3 cm in diameter. If the soil pH is over 6 then foliar sprays are essential to obtain a marketable crop. *Manganese* — may be a problem where pH's are high on sandy soils. Control may be obtained with a number of sprays of manganese sulphate.

Application Method — Fertilizers at high rates are best broadcast and incorporated prior to planting. Fertilizer placed too close to the root will result in excessive root formation, misshapen roots and consequently high cullage rates.

Pests and Pest Control

Weeds

Herbicides recommended for use on rutabagas will not provide total weed control, therefore, it is important to grow rutabagas in soil where the weed seed population is low. This is best accomplished by a crop rotation program utilizing crops where weeds can be thoroughly controlled for a year or two prior to rutabagas. Stale seedbed technique can be used to considerable advantage on late seeded rutabagas. Care must be taken to avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur. Cultivation is required to supplement chemical weed control.

Diseases

Downy Mildew (fungus)

Characteristics: Shows as a white, fuzzy fungus in patches on underside of leaves, stems and heads. The fungus overwinters on seed, in cruciferous weeds and perhaps soil. May cause internal discoloration of roots.

Control: Plant hot-water-treated seed. Avoid thick or heavy seedings. Plow crop residue following harvest. If infestions are severe rotate with non susceptible crops.

Clubroot (fungus)

Characteristics: Causes wilting and yellowing of above ground parts. Large spindle shaped galls form on the roots. The fungus causing clubroot in rutabagas and cole crops is usually present in areas where these crops have been grown for many years. Land will remain infested for 7 years or longer after a diseased crop. Certain weeds of the mustard family, such as wild radish and wild mustard (cadlock) will maintain or increase the level of infestation year after year. Every effort should be made to control weeds of this family. Soil pH of less than 7.2 favors the disease.

Control: Avoid fields known to be infested and practice a rotation of 7 years once infestation has been encountered. Do not use manure from animals fed on infected crops on land intended for rutabagas or any cole crop. Put manure back on the fields that contained the infected roots and do not grow any cole crop on the field for at least 7 years. Grow resistant varieties. York is resistant in most areas of P.E.I. and

southern N.S. A strain of the organism present in the Amherst, Parrsboro, and Sussex areas of NS and NB and in parts of Newfoundland, will cause clubbing in York. Even when growing a resistant variety, practice a 3 year rotation between cruciferous crops. Do not rely on resistant varieties alone.

Skin Rot (fungus) & Common Scab (Bacterium)

Characteristics: Rhizoctonia and scab, which are well known as diseases of potatoes, may cause quite severe damage to rutabagas. If these diseases are present in the soil, they may be much more severe where insecticides are not used to control root maggots. Rhizoctonia also develops further in roots kept under poor storage conditions.

Control: Practice crop rotation, such as: potatoes, grain, and one year of hay; then plow early, keep land free of weeds in the fall, and plant rutabagas the following year, do not use manure from cattle fed on diseased roots on land to be sown to rutabagas. Keep storage temperature between 0°C and 2°C.

Blackleg (fungus) and Black Rot (bacterium)

Characteristics: Early signs of blackleg appear as small spots on leaves of young plants. On stems the spots are more linear and often surrounded by purplish borders. Stem lesions at the soil line usually extend to the root system causing dark cankers. The fiberous root system may be destroyed although new roots sent out above the lesion may keep the plant alive. Plants may wilt abruptly and die. Dark cankers may develop in fleshy roots of turnip and rutabaga or may develop as a dry rot on stored roots.

Black rot lesions first appear at margins of leaves. The tissue turns yellow and the lesion progresses toward the center of the leaf, usually in a v-shaped pattern with the base of the v toward the mid rib. The veins become dark and discoloration frequently extends to the main stem and proceeds upward and downward. Black discoloration of rutabaga roots may occur.

Control: Use hot water treated seed or seed treated with an antibiotic. Practice a 4 year rotation. Destroy cruciferous weeds as they may harbour the black rot organism.

Water-Core or Brown Heart

Characteristics: Caused by boron deficiency. Appears at first as firm, water soaked patches in the rutabaga flesh. May eventually turn brownish and punky inside.

Control: Apply boron with the fertilizer and/or as foliar sprays.

Insects

Root Maggot

Characteristics: The adult is a two-winged, ash-grey fly with black stripes on the mid-section. It is half the size of a housefly, but has longer legs. Larvae are white, legless maggots. They are wedge-shaped with dark feeding hooks at the pointed front end. The pupae are 6 mm long, oval, hard shelled and dark brown. There are two to three generations a year. Pupae overwinter in the soil near the roots of the host plant. Adult flies emerge in the spring and crawl to the surface. They fly close to the ground near host plants and lay elliptical white eggs on the stems or in nearby crevices in the soil. Eggs hatch in three to seven days. Maggots enter the roots and feed by rasping the plant tissue with a pair of hook-like mouthparts. They mature in three to four weeks and pupate. Flies emerge in two to three weeks. Larvae or maggots feed by tunnelling in the roots. Plants may be killed, weakened or stunted, and yields reduced. Plants that are killed, wilt, have a grey overcast and remain in place in the row unlike those severed at ground level by cutworms. A small amount of tunnelling in rutabaga or radish lowers the grade or renders the crop unmarketable.

Control: Practice crop rotation, and grow the current year's crop as far as possible from fields used for rutabagas or cole crops last year. Do not grow crops of early and late rutabagas close together. Separate them by at least 200 meters. Apply insecticides as listed in publication 1400A.

Wireworm

Characteristics: Early in the spring, adult wireworms (click beetles) lay their eggs around grass roots. The larvae hatch in about a week and will live for 2 to 6 years in the ground feeding on roots and seeds. The wireworms, or larvae, are yellow, white or darker shades of brown. They may be 1.2 to 4 cm long and have a hard, smooth surface. When a larva is mature, it pupates in the fall. It then becomes an adult beetle and waits until spring to emerge. Wireworms are often numerous in land that has been in sod for several years. See appendix III in the supplement to this guide. These are sometimes confused with millipedes which have numerous pairs of legs and coil up when disturbed.

Control: Plant treated seed and avoid planting crops highly susceptible to wireworms in a field that has been recently in sod.

Aphids

Characteristics: Aphids are small, soft-bodied, slow-moving insects. They are often found in large colonies on the undersurface of leaves. A colony consists of winged and wingless adults and various sizes of nymphs. Aphids may be black, yellow, or pink but mostly are various shades of green. Aphids feed by sucking plant sap. Saliva injected while feeding may carry plant viruses or may be toxic to the host plant. Feeding by large numbers discolors foliage, curls leaves and damages developing buds. The plants may be covered by a sticky substance, honey dew, which is excreted by the aphids.

Control: Spray only if aphids are so numerous as to cause wilting of leaves during dry weather. Predators

such as lady bird beetle (colored orange with black stripes or spots) and their larvae (black or purple with orange or white markings) may control severe attacks of aphids.

Cabbage Looper, Imported Cabbage Worm, Diamondback moth larvae, Purple Backed Cabbage Worm

Characteristics: The adult of the Imported Cabbage Worm is a white butterfly easily seen going from plant to plant laying eggs during the summer. The eggs become velvety-green larvae with one thin yellow stripe down the center of its back. The cabbage worm larvae does not loop when it walks. They are generally the most prevalent of the cabbage larvae.

The cabbage looper gets its name from the way it loops as it walks. It is a smooth green larvae with pale yellow stripes along the back and sides. They are heavy feeders.

The Diamond-Back Moth is much smaller than the previous insects. Three to six generations of 1.1 cm green larvae may develop each year. The larvae squirm actively when disturbed and produce many small holes on the host plant.

The Purple-Backed Cabbage Worm is not as commonly seen as the others but will cause serious damage in high numbers. The larvae are purple on the back and pale yellow along the sides. There are two generations per year.

Control: If worms are causing severe leaf damage, use one of the recommended insecticides.

SPECIFIC CHEMICAL CONTROLS FOR THE VARIOUS CROP PESTS DISCUSSED MAY BE FOUND IN THE SUPPLEMENT TO THIS GUIDE, A.P.A.S.C.C. PUBLICATION 1400A, "A GUIDE TO CULTIVAR SELECTION AND CHEMICAL PEST CONTROL FOR VEGETABLE CROPS."

Harvesting and Handling

The quality and flavor of rutabagas are much improved when the roots are fully matured or are exposed to a slight frost before harvesting. Immature roots have a bitter taste, and if early seeded rutabagas are left in the field until late fall the roots tend to become fibrous and woody.

Certain types of potato diggers can be readily adapted for harvesting rutabagas, but before you start to dig remove the tops with the aid of a topping device. Crops can also be harvested by using a modified sugar beet or carrot harvesting machine. In preparation for long-term winter storage (6 to 8 months), trim the tops to within 1 cm of the body and cut off the bottom of the taproot and the fibrous side roots. Protect newly harvested rutabagas from sunburn and freezing at all times and handle them gently to avoid bruising.

Mechanical harvesters tend to spread bacterial and fungal organisms, particularly if the crop is not dried within a week or two after harvesting, to crowns and mechanical wounds on roots. To minimize rot in the crown rutabagas should be topped a week or 10 days before harvesting, with a hoe, knife or mechanical topping machine.

Storage and Conditioning

Rutabagas may be piled up to 2 m deep over a slatted floor with an air circulation system to keep the temperature uniform. Perforated plastic sheeting placed horizontally at 45 cm intervals helps to reduce moisture loss and excessive accumulation of moisture at the top of the pile or on the roof of the storage area.

To obtain best results, lower and maintain the storage temperature close to 0°C and keep the humidity at 90% or higher. Under these conditions, rutabagas keep for over 6 months, the flavor of rutabagas is improved by the conversion of starch to sugar, reducing strong or bitter flavor. This chilling may occur in the field or in storage.

In Atlantic Canada rutabagas are commonly washed. In Central Canada they are frequently waxed to prevent loss of moisture during marketing. Shelf life is also prolonged by plastics. Waxed rutabagas are considered to have a greater eye appeal and greater consumer demand that unwaxed ones. Temperatures must be kept low after waxing as waxed rutabagas spoil quickly at room temperature.

An alternative method is to place rutabagas in perforated plastic containers to prolong shelf life. Rutabagas in plastic bags have been kept at room temperature for 6 weeks without apparent deterioration compared with 3 to 4 days for waxed ones under the same conditions.

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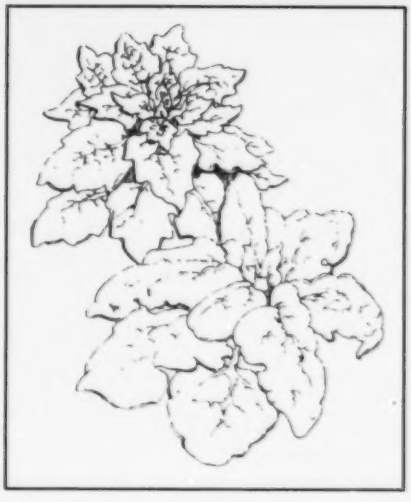
Spinach



Introduction

Spinach is a member of the Chenopodiaceae (goose foot family). Other vegetable crop members of this family are Swiss Chard and Beets. *Spinacia oleracea* is a low growing fleshly leaved annual that forms a heavy rosette of broad, crinkly tender leaves. This vegetable plant's cultivation began in Iran around 400AD. The Arabs introduced spinach into Spain in 1100 AD and it spread to the rest of Europe by 1400 AD.The first savoyed leaf variety was introduced into North America in 1828.

Spinach prefers a cool climate. The minimum temperature for seed germination is 2°C with a maximum germination temperature of 30°C and an optimum range of 7 to 24°C. Young plants can withstand temperatures as low as −9 degrees C. Best crop growth occurs at 15 to 20°C with a minimum temperature of 10°C and a maximum of 32°C. In the Atlantic region spinach is grown in the spring from April and May seeding to mature from June 1st to mid July. The crop is also seeded in August and early September (up to 30-35 days before the first fall frost) for September and October harvest. This crop may also be overwintered if given protection and/or favorable winter weather. (a snow cover). Spinach bolts rapidly when days are both long and hot. Plants reach market size in 40 to 70 days depending on the temperature, moisture, fertility, etc. Spinach requires a regular supply of moisture since it is a shallow rooted crop.

Spinach can be grown on a variety of soils. Well drained sandy loams or loams well supplied with organic matter and high in pH are preferred for the early and wintered over crops because of good drainage and early soil warming. Peat soils may also be used and produce the highest yields.

Harvest of spinach usually begins the first week of June and continues until mid July or as long as weather and cultivar dictate. The fall crop can start in early September and extends up to late October depending on the local microclimate (fall frosts). Yields vary from 10,000 kg to 20,000 kg per hectare. Generally the more savoyed leaved cultivars are used for fresh markets and the smoother leaved ones for processing. The use of tunnel houses could lead to earlier spring production (mid May).

Currently spinach is a minor crop with most of the crop grown for roadside markets or delivered directly to retail stores. It is a crop that has increased in popularity as a salad crop and so there would seem to be potential for additional wholesale markets. It is also a potential processing crop.

Crop Establishment

Seed Treatment — Seed can be sized to be precision seeded. Fresh seed will germinate readily at soil temperatures as low as 3 to 4°C and good results are obtained at 10 to 16°C. At higher temperatures there is a more rapid emergence but a decreased percentage germination. Spinach seed more than a year old rarely germinates over 80%. Older seed is even less viable and germinates more slowly and irregularly.

Seeding/Planting — Sow at a rate of 13 to 17 kg of seed per hectare when using non-precision seeders. Less than one-third of this will be needed if the crop is precision seeded. Sow seed at a depth of .5 to 1 cm and at a spacing of 25 seeds per meter of row for fresh market production and up to 40 per meter of row for processing production. Rows may be spaced 18 to 60 cm apart depending on cultivation equipment and plant population. Seed may be broadcast where weed control is not a problem.

Nutrient Content: Very good source of Vitamins A and C; good source of potassium, folate and iron. 250 mL (1 cup) cooked spinach provides 42 kilocalories; the same amount served raw supplies 8 kilocalories.

Crop Management

Irrigation — on sandy soils irrigation should be provided if 2.5 cm per week of rainfall is not received.

Nutrition

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If spinach is stressed by a lack of nutrients, vegetative growth is retarded and the plants are more prone to bolting.

Manures — due to the weed seed contained in manures and the lack of effective herbicides, manures are

not recommended. Also the nitrogen availability from manure is erratic for such a short season crop. Soils are also cold during the times spinach grows best. The fertility from manure is most available when soil temperatures are warm.

Lime — Lime should be applied to maintain the soil pH in the range 6.5 to 6.8. Spinach is extremely sensitive to soil acidity.

Nitrogen — since spinach is such a short season crop and it is grown when soils are relatively cool at least half the nitrogen in the fertilizer should be in the nitrate form. If nitrogen sidedressing is possible up to 50 kg of actual nitrogen per hectare can be applied 3 weeks after seeding. Do not apply nitrogen later than this as nitrate will accumulate in the leaf tissue. Urea may be applied as a foliar spray for part of the nitrogen requirements.

Phospborus — As with most vegetable crops banded phosphorus would be ideal due to its close proximity to developing seedling roots. This crop has a relatively high requirement for phosphorus.

Potash — spinach is a heavy feeder in regard to potash especially at high yield levels.

Magnesium — a foliar application of magnesium may enhance the production of dark green leaves. Apply 12 to 15 kg of epsom salts per hectare. Magnesium deficiency has similar foliar symptoms to nitrogen deficiency (yellowing on older leaves). Use dolomitic limestone on fields to be cropped to spinach.

Micronutrients

Manganese — deficiency here usually occur due to overliming of the soil. This can be corrected with foliar sprays of manganese sulfate.

Boron — spinach is quite susceptable to boron deficiency. Apply boron in the fertilizer and as a foliar spray or soil drench.

Molybdenum — may be required especially where the soil is acid.

Application Method — broadcast the fertilizer and work into the soil preplant or band 5 cm below and 5 cm to the side of the seed row. Only band a portion of the potash. The balance of potash requirements should be harrowed into the soil prior to planting. Apply sidedressings or foliar nutrients if required.

Pests and Pest Control

Weeds

Recommended herbicide will control only a small number of weed species. Annual and perennial weed populations must be reduced prior to planting. A number of shallow cultivations are an essential part of a weed control program. Manure should not be used on this crop due to its high weed seed content. Herbicides should be ordered early as they many not be readily available at planting time. Care must be taken to avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur.

Diseases

Downy Mildew (fungus)

Characteristics: Causes indefinite, yellowish areas on the upper leaf surface. On the lower surface a gray mold appears. Affected areas turn black and die. Disease develops best in cool, moist weather.
Control: To control this disease use tolerant cultivars. Practice 3 year crop rotations and hot water treat the seed.

Fusarium Wilt and Root Rot (fungus)

Characteristics: Plants turn yellow and wilt, beginning with older leaves. The fungus attacks feeder roots first and then the tap root.
Control: Do not plant the crop when the soil temperatures are high (mid June to late August). The cultivar "Packer" has some tolerance.

Spinach Blight or Yellows (virus)

Characteristics: Caused by cucumber mosaic virus and transmitted by aphids. Young inner leaves become mottled, later changing yellow and finally they are killed. Older leaves gradually turn yellow. Symptoms develop much faster at higher temperatures.
Control: Grow resistant cultivars.

Insects

Spinach Leaf Miner

Characteristics: The adult is a slender grey fly 4 mm long. They are frequently seen hovering over the host plants. Small green or white maggots feed inside the leaves, forming blotches. There are several generations a year; pupae overwinter in the soil. Flies lay eggs on the undersides of the leaves. Larvae enter the leaves, feed until mature, then drop to the ground, pupate, and emerge as flies. Colorless blotches with a silvery overcast are formed by the larvae mining between the surfaces of the leaves. This makes the crop unmarketable. Heavy infestations stunt growth.
Control: Insecticides should be applied when mining damage is first observed. Two to three treatments at 10-day intervals may be needed. Early in the season infestations may be suppressed by destroying infested crop residues and weeds.

Aphids

Characteristics: Aphids are small, soft-bodied, slow-moving insects. They are often found in large colonies on the undersurface of leaves. A colony consists of winged and wingless adults and various sizes of nymphs. Aphids may be black, yellow or pink, but mostly are various shades of green. Aphids feed by sucking plant sap. Saliva injected while feeding may carry plant viruses or may be toxic to the host plant. Feeding by large numbers discolors foliage, and curls leaves. The plants may be covered by a sticky substance, honey dew, which is excreted by the aphids.
Control: Spray only if aphids are so numerous as to cause wilting of leaves during dry weather. Predators

such as lady bird beetle (colored orange with black stripes or spots) and their larvae (black or purple with orange or white markings) usually control severe attacks of aphids.

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Harvesting and Handling

The entire plant is usually harvested by cutting just above the ground level when there are at least 5 - 6 leaves. Cutting should take place at the coolest time during the day and when the plants are dry. The crop should be harvested before the seed stalks overmature.

For the fresh market it is usually placed loose into pallets and then washed and cooled as quickly as possible. Spinach may be hydrocooled or bagged into retail packs and iced. Spinach has one of the highest respiration rates among fruits and vegetables so cooling is critical. Forced air cooling can be used on this crop.

Storage

Spinach can be held 10 to 14 days at a temperature of 0°C and a relative humidity of 90 to 95%.

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(See also General References)

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Squash and Pumpkins

Introduction

All pumpkins and squash are members of Cucurbitaceae (gourd family) as are watermelons, cucumbers, muskmelon and gourds. Botanically there is no distinction between squashes and pumpkins since both pumpkin and squash cultivars are found in these species:

Cucurbita Species	Summer Squash	Winter Squash	Pumpkin	Marrows
C. pepo	X	X	X	X
C. mixta	—	X	X	—
C. moschata	—	X	X	—
C. maxima	—	X	X	X

Pumpkins and squash originated in the Americas and were cultivated by the ancient civilizations of Central and South America for approximately 7000 years. All 4 species seem to have originated and been cultivated in different areas of North and South America for many purposes — edible seed, containers and edible fruit. Summer squash - is the edible fruit of any species of cucurbita (commonly *C. pepo*) utilized when immature as a table vegetable. The rind and seeds are soft and the vegetable is 100% edible. Winter squash - is the edible fruit of any species of Cucurbita utilized when ripe (usually *C. maxima* or *C. moschata*) as a table vegetable or in pies. The flesh is fine grained and of mild flavor so is suitable for baking. The fruits have hard rinds and store well. Pumpkins - are the edible fruit of any species of curcurbita (usually *C. pepo*) utilized for Hallowe'en, livestock feed or in pies. The flesh is somewhat coarse and may be strongly flavored and is not generally served as a baked vegetable.

Pumpkins and squash are warm season crops which are both cold weather and frost sensitive. They are more cold hardy than cucumbers. The minimum temperature for seed germination is 15°C, with a maximum of 38°C and an optimum range of 20 to 32°C. Best crop growth occurs at 18 to 25°C, with a minimum of 10°C and a maximum of 32°C. Cultivars requiring a long growing season should only be planted in the regions where grain corn can be grown, in fields which are sheltered since cold winds are detrimental to growth. Plastic tunnels, row covers and/or plastic ground mulches benefit these crops.

Well drained loams well supplied with organic matter are optimal for early production. Heavier soils may be used, if they are of good structure, for late season and storage production. These fields will usually be rotated from a perennial forage crop the previous growing season.

The market season varies for each type and cultivar of pumpkin and squash.

1) *Summer squash* (mainly zucchini) can be produced from July 1 to Oct. 15 with some use of plastics. Yields may range between 10,000 to 15,000 kg per hectare.

2) *Winter squash* (mainly buttercup) can be produced and marketed from July 20 to May 30. Yields may range from 15,000 to 25,000 kg per hectare depending on the weather, cultivar and storage losses.

3) *Pumpkins* (mainly *C. pepo*). The bush type tend to be earlier than vine types and start to mature and yellow in mid to late August. The main crop should be mature by September 15th for curing and storage for sales until Hallowe'en. Pumpkins may be stored beyond October 31 but there are only limited markets. Pumpkins vary in yield from 20,000 to 40,000 kg per hectare depending on the weather, cultivar and storage losses.

Squash and pumpkins are mainly sold at roadside or through retail stores. Some go through wholesalers. Squash are stored for roadside and wholesale markets from October to early March or beyond. Hubbard squash store better than most buttercup but the market for this type is not large. Some buttercup cultivars store better and have a much drier texture to the flesh. Markets for winter squash are mainly served from local production but there is some potential to replace winter imports with the use of storage buttercup squash.

Zucchini is the most popular of the summer squashes and its popularity continues to grow. Current marketings are mainly roadside and direct to retail stores. Eventually more market may be available so that wholesale volumes of this crop can be produced.

Pumpkins are marketed mainly at roadside and through retail chain stores. Some get into the wholesale market. There are a great range of size and types

of pumpkins so some speciality markets may be developed for certain types for carving, other ornamental or other traditional uses. The market is supplied mainly from local supplies and strength of the market depends on seasonal weather and local plantings. Generally in pumpkins and squash there are limited market potentials to reduce imports, increase consumption and produce specialty products for retail shelves or the Hotel, Restaurant & Institutional Industry.

Nutrient Content: Excellent source of Vitamin A; good source of Vitamin C; potassium and calcium. Low in sodium. Amount of kilocalories in a serving depends on the type — 250 mL (1 cup) cooked, mashed winter squash contains 137 kilocalories; cooked-diced summer squash contains 27 kilocalories; cooked pumpkin has approximately 79 kilocalories. The seeds are a good source of protein; and contain some iron.

Crop Establishment

Seeding/planting — Do not plant until the soil temperature is at least 16°C. Some types of vegetable seeders can be adapted to effective seeding of some cultivars of pumpkin and squash. The seeding rate depends on the seed size, whether it is running or bush type, on the actual spacing and whether transplants are used vs. direct seeding:

For vine types 2 to 5 kg per hectare and bush types 4.5 to 6.5 kg per hectare. Space rows 1.5 to 2 m for buttercup, 2 to 2.5 m apart for pumpkins and hubbards, and 1 to 1.5 m apart for bush pumpkins and summer bush squash. Plants should be spaced at .5 to 1 m for buttercup, 1 m for pumpkin and hubbards, and .6 to .9 m for bush pumpkins and summer squash. The depth of sowing should be 25 to 30 mm.

Generally thinning is less critical than with most vegetable crops since higher plant populations usually result in smaller fruit but similar yields.

For transplants seed two to four weeks before field setting in individual containers such as peat pots, peat blocks or peat pellets. Do not transplant until the danger of frost is low. Plastic row covers or walk-in tunnels are being used by roadside marketers and specialty crop growers to capture more market.

Crop Management

Plastics — For direct seeded or transplanted pumpkins or squash black or clear ground mulch, hot caps, plastic row covers, and/or tunnel houses can be used effectively to get early production. Economics dictate what is feasible for each type of cultivar for specific markets. Tender transplants must be protected from wind injury.

Pollination — This is an important concern for a good set of high quality fruit. On winter squash and pumpkin, fruit set takes place over a 2 to 3 week period. Inadequate pollination results in poorly shaped fruit as well as excessive blossom drop. One colony of honey bees per hectare is suggested. Most insecticides will poison bees so take precautions.

In contrast to open pollinated varieties, most of the summer squash tend to develop female flowers before the male flowers appear, especially in cool weather. As a result some of the earliest flowers may not be fertilized unless there is another source of pollen. Unfertilized fruits may enlarge somewhat, but seldom reach marketable size, shape or quality.

Irrigation — These crops under moisture stress are generally responsive to irrigation especially from the time of fruit set to harvest. When using row covers, tunnel houses or hot caps fixed irrigation systems can help prevent frost damage.

Nutrition

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Pumpkins and squash usually respond well to applications of 20 to 40 tonnes of manure per hectare. Otherwise a green manure crop or sod plow down is desirable. When a limited amount of manure is available 8 to 10 tonnes may be buried beneath the seed row.

Lime — Lime should be applied to maintain the soil pH in the range 6.0 to 7.0.

Nitrogen — one-half of the nitrogen is usually applied at planting time unless the soil is low in P and K and large amounts of fertilizer need to be applied. The remainder of the nitrogen is sidedressed just as the vines begin to run for winter squash and pumpkins (early July) and when bush squash have developed sizable plants (late June). A second sidedress may be needed on sandy soils which have been leached by high rainfall. Foliar applications of nitrogen are possible especially on summer squash which are being intensively cropped.

Phosphorus — banded fertilizer would be effective at reducing the need for phosphorous. Plant starter (with high phosphorus) is needed on transplants for early crops.

Potash — the requirement for this nutrient is not high especially if good quality manure is applied. Do not band potash (if possible) but broadcast and harrow it into the soil preplant. If potash is banded do not apply more than 100 kg of N plus potash per hectare.

Magnesium — If soil magnesium levels are low, a fertilizer containing magnesium may be used. Foliar sprays may also be used.

Sulfur — On sandy soils low in organic matter that have been intensively cropped, soil sulphate levels may be low. Application of gypsum should be considered on these soils.

Application Method — Up to 100 kg of (N + K) per hectare can be applied in a band, 5 cm to the side and 5 cm below the seed at planting with the remainder of the fertilizer broadcast and incorporated before planting. Nitrogen may also be sidedressed or applied to the foliage.

Pests and Pest Control

Weeds

Successful weed control in squash and pumpkins is possible by integrating chemical and cultural techniques. These crops should be planted to land free of perennial weeds, where the annual weed seed population has been reduced through previous cropping and tillage prior to planting. Recommended herbicides may not provide control for the entire season, therefore cultivation may be necessary. Avoid fields where residual herbicides from previous years persist in the soil as crop injury may occur.

Weeds can be controlled in squash and pumpkin by planting seed or transplants in opaque plastic mulch. Consult your local agriculture office for information on weed control between the rows of plastic mulch.

Diseases

Alternaria and Septoria Leaf Spot (fungi)

Characteristics: *Alternaria* causes small circular spots which enlarge up to 2 cm in diameter with dark concentric rings within the spots. Spots may coalesce to affect larger areas of the leaf. Black sunken lesions may occur on the fruit. *Septoria* causes numerous small lesions with white centers which may lead to defoliation. These fungi will overwinter in soil for one season and possibly 2 years. Both probably are seed borne as well.

Control: Treat seed and rotate with non-cucurbit crops. Apply appropriate fungicides at first sign of the leaf spots and at 7-10 day intervals.

Black Rot and Gummy Stem Blight (fungi)

Characteristics: Both are caused by the same fungus. When the fungus is seed borne it causes damping-off which usually kills the seedlings. On older plants it spots the fruit, foliage, petioles and stems. On fruit the spots are circular, yellow to light green in color eventually turning gray to brown to finally black. Spots on leaves are pale brown, while those on stems form streaks having an amber exudate. The fruit rot phase often develops on stored pumpkins and squash. The fungus overwinters in seed and residue from diseased plants.

Control: Plow down refuse immediately after harvest. Follow at least a two year rotation. Apply fungicides at first sign of disease and at 7-10 day intervals. Post harvest fruit rots can be reduced by careful handling, curing and storage temperature control.

Powdery Mildew (fungus)

Characteristics: Appears as a white powdery growth on leaves which may cause the leaves to wither and die. It is favored by high temperatures.

Control: Apply appropriate fungicides at first sign of disease and at 7-10 day intervals.

Fruit Rots in Storage (fungi)

Characteristics: A number of diseases attack pumpkins and squash in storage. Black rot, *Sclerotinia*, *Alternaria*, *Rhizopus*, *Botrytis*, *Fusarium*, *Penicillium* and *Cladosporium*. All may occur as fruit rots in storage. Rots can originate from actual fruit infection in the field or from a dusting of fungus spores that later infect the fruits in storage.

Control: Involves the season long practices of seed treatment, good field drainage, rotation, insect control, fungicide sprays, harvest care and especially post harvest storage temperature and humidity control. Harvest only mature fruits, prior to frost or chilling temperatures and cure properly and store at 7.5 - 13°C.

Virus Diseases

A number of diseases affect squash and pumpkins and the symptoms are often similar. Cucumber mosaic is the most common virus disease. CMV affects many vegetables and other plants not related to squash and pumpkins. Younger leaves develop a dark green, yellow mottled and wrinkled look. Older leaves may gradually turn yellow and die but in many plants these leaves stay green and only the younger ones have mosaic symptoms. Yellow warts may form on the fruit.

Control:

Eliminate weed hosts and apply insecticides to control aphids.

Insects

Seed Corn Maggots

Characteristics: Small yellowish-white maggots 6 mm long with a pointed head end. The adult is a small grayish-brown fly. Maggots feed on seed, causing seed to produce a poor plant, and will also feed on roots, causing poor plant growth. Seed corn maggots attack deeply planted seeds.

Control: Plant as shallow as needed in a well prepared seedbed. Early germination is necessary to get good plant stands and prevent injury. Later planted crops are not as susceptible to this pest. Good weather conditions are necessary to completely control the pest. Avoid planting susceptible crops in fields very recently manured. Chemical seed treatment is essential.

Striped Cucumber Beetle

Characteristics: The striped cucumber beetle overwinters in the adult stage under leaves or dense grass, emerging in May or early June. The adult is 5 mm long. Its upper surface is about equally black and yellow, with the folded wing covers bearing three black stripes. Two weeks after emerging the beetles mate and lay eggs. The orange-yellow eggs are laid in the soil at the base of host plants and hatch within 10 days. Upon hatching, the larvae burrow into the soil and start to feed on roots. About the first of August the larvae pupate in the soil. Two weeks later, a new generation of beetles appear. In Canada, there is only

a single generation per year. They are a carrier of bacterial wilt.

Control: Apply insecticides when insects first appear and repeat as necessary.

Flea Beetle

Characteristics: Flea beetle adults are 1.5 to 3 mm long, black or bronze beetles. Their hind legs are well developed for jumping. The white larvae are in the soil, and therefore seldom seen. Depending on species, there are one or two generations a year. Adults overwinter in the soil. Eggs are laid on or near the roots where larvae feed. Mature larvae pupate in the soil near the host plant. Adults emerge in early August for single-generation species. Last-generation adults feed on foliage until fall, when they return to the soil to overwinter.

Control: Heavy damage can occur quickly, so prompt attention is necessary when an infestation is seen.

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Harvesting and Handling

Winter Squash - Harvest for roadside begins when maturity is reached. That is when the fruit sizes up and then takes on a dull waxy appearance. For storage harvest should take place before the vines are frosted. The stems should be cut to 50 mm in length. This step will aid in a quick curing process, and fungal infection of the fruit by means of the stem will be avoided. (Plant only long storing buttercup cultivars such as "Delica".) Place fruit in appropriate bulk bins which will give good air circulation in the curing process. In bright sunshine sun burn can occur on harvested fruit. Market size is generally 1 - 3 kg.

Pumpkins - Harvest with appropriate sized handles 5 - 10 cm before the first frost into bulk bins. Proper curing and storage maintains good handles, faster ripening, and better color.

Summer Squash (Zucchini) - This vegetable is harvested immature approximately 180 mm in length with an approximate diameter of 50 mm (approximately 10 per kg). Some markets may call for smaller sizes. A sharp knife is required for harvest. Harvest is at 1 - 3 day intervals. Fruit should be removed from the plant as this increases the plants productive life and marketable yields.

Storage and Conditioning

The general storage conditions for these crops are a temperature of 7.5 to 13°C and a relative humidity of 70 to 75%. The storage life of winter squash ranges from 2 to 6 months depending on the cultivar. Most cultivars of winter squash store longer than pumpkin cultivars. After curing, for about 2 weeks, at 27 to 30°C, maintain the storage at 7.5 to 13°C and at 60 to 75% relative humidity. Curing hardens the shell, heals superficial wounds, reduces the water content of the fruit and thereby improves the eating quality. A temperature of 2°C for 30 days will result in chilling injury, exhibited by increased rot, when removed from storage to room temperature. Summer squash has a short storage life, not over two weeks. It should be stored at 10 to 13 degrees C at a relative humidity of 95%.

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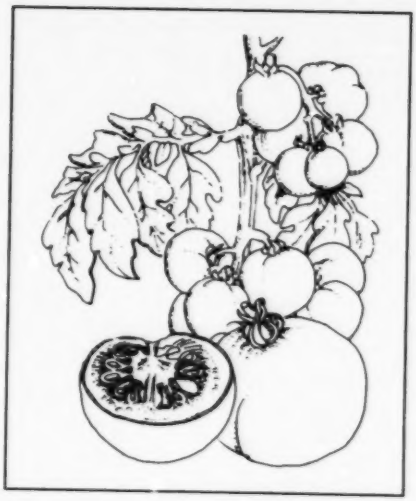
Tomatoes



Introduction

Tomatoes belong to the Solanaceae (the nightshade family) along with potatoes, peppers and eggplants. *Lycopersicon esculentum* is a perennial plant in the tropics but in northern climates it is grown as an annual. Botanically this vegetable is a fruit (a berry). Flowers are generally borne in clusters of 4 to 8 but small fruited types may have 30 to 50 flowers per cluster. The flowers are mainly self pollinated by the wind. The fruit has 2 to 18 locules (chambers or sections).

The tomato is a native of the Peru, Bolivia, and Equador area of the Andes Mountains. Its antiquity is uncertain in regard to cultivation but it was being cultivated when America was discovered by Europeans. It was not until 1835 that the tomato was considered suitable as a food crop in the northeastern U.S.

Tomatoes respond well to high temperatures. The minimum temperature for seed germination is 10° C with a maximum temperature of 35° C and an optimum range of 17 to 20° C. Most field transplants should not be set out until the danger of frost is past. An optimum growth rate is obtained at 22° C with reductions occurring above 30° C and below 12° C. Fruit setting is inhibited above 30° C and below 16° C. Rough fruit results from growing temperatures below 16° C. Root growth does not occur below 16° C. Tomatoes require adequate, even moisture, particularly at flowering and during fruit set.

Tomatoes grow best in well drained soils that are well supplied with organic matter. Sandy soils are suited for early production, loam and clay loam soils are suited for later production. Shelter from wind is important for early production. This crop also benefits from the use of plastics such as ground mulches, row covers, and tunnel houses.

Tunnel house tomato harvest begins about mid-July and field harvest about August 1st. Production continues as long as economically viable, usually up to late October. Marketable yields of ripe tomatoes vary dramatically with the weather. This range is 10,000 to 30,000 kg per hectare. Tomatoes for green chow may yield as much as 40,000 kg per hectare.

There is a large market for red tomatoes in the Atlantic area within our growing season, especially on the wholesale market. There is still price competition from other areas of North America and in good growing seasons, market "gluts". There is also interest in extending our season with the use of tunnel houses for July and August production. There is a limited market for fresh green tomatoes and a limited processing market. At the present time yields of red processing tomatoes are not high enough to be economically viable.

Seeding/Planting — Since tomatoes require a relatively long growing season, they should be started in a greenhouse or hotbed. Approximately 75 to 150 grams of seed are required to produce enough plants for one hectare. Sow seeds eight weeks before plants are to be set in the field or tunnel. A temperature of 27°C for 1 to 2 weeks is required for good seed emergence.

Plants for early crops can be pricked off (when the first true leaves appear) into 5 to 10 cm pots and plants for late production can be pricked off into a module transplant tray, peat block, paper pots or peat pots 4 to 5 weeks before transplanting. Plants should be grown firm and stocky by good light, moderate temperatures and appropriate fertilization. Plants should be developed to the budding stage by the time of transplanting.

Tomato plants can also be raised by sowing raw seed directly into peat pots, module trays, or peat blocks. Under such a planting system a superior plant can be raised in a shorter time. This system is less labor intensive and reduces transplant shock.

Tomato plants should be hardened for about one week before transplanting to the field. This can be accomplished by reducing the soil moisutre supply and reducing the air temperature to 13 to 16°C. This will improve the survival ability of the plants to adverse weather conditions when field set.

Tomatoes are normally field set at 11,000 to 18,000 plants per hectare depending on the type of tomato and its field spacing:

(1) Determinate (small-vined) cultivars — plants 45 to 60 cm apart, rows 1 to 1.5 m apart.

(2) Indeterminate (larged vined) cultivars - plants 50 to 90 cm apart, rows 1.5 to 2 m apart.

(3) Staked Tomatoes - plants 45 cm apart, rows 1 to 1.5 m apart.

Nutrient Content: An excellent source of Vitamin C. They are also a source of many minerals including potassium, calcium and folate. One medium raw tomato provides 35 kilocalories.

Crop Management

Transplanting — set in the field after the danger of frost is past. Set out only relatively young, tender and blossom free plants. Severe hardening reduces yields. To obtain good yields and fruit size, the plants should become established in the field before the first fruits are set. This is important with early determinate cultivars. Use a starter fertilizer solution.

Mulching — black plastic mulch can be used for weed control and higher yields of marketable fruit. Clear plastic mulch is the most effective for early growth and yields. However, weeds must be controlled with the use of herbicides.

Hot caps, row covers or tunnels — These are used by growers to foster early growth and production. Ventilation is critical on warm sunny days. Do not allow temperatures around plants to exceed 35°C. Grow cultivars suited to this method of culture.

Staking Tomatoes — advantages in staking, or otherwise training tomato plants off the ground include a frequent increase in the percentage of marketable fruit, easier harvesting, and reduced injury to both plants and fruit in harvesting. It is doubtful that staked yields will differ from unstaked plant yields or that fruits on staked plants are firmer. Staking procedures that require little pruning seem best because pruning is costly; since removing laterals means removing potential flower clusters, both early and total yields per plant are often reduced. The practices of staking and pruning most are likely to be profitable when a long harvest season is possible and fairly uniform production over the season is desired. (only staking greenhouse cultivars should be used in tunnel houses and a limited number of trusses should be allowed to set depending on the intended market and season)

Irrigation — the soil moisture should be kept at a reasonable level to reduce the incidence of cracking and blossom end rot from wide flucuations in soil moisture. A fixed irrigation system may be used for frost control at planting time or late in the fall. Trickle irrigation may be used in the field or in tunnel houses with or without soil mulches.

Nutrition

ALL ADDITIONS OF LIME AND FERTILIZER OR MANURES SHOULD BE BASED ON RECOMMENDATIONS FROM A SOIL TEST. WHEN TEST RESULTS ARE NOT AVAILABLE THE GENERAL REQUIREMENTS FROM TABLES 1 - 4 OF THE SOIL AND WATER MANAGEMENT SECTION OF THIS GUIDE MAY BE FOLLOWED.

Manures — Often they are used in tomato production but one has to be careful of excessive nitrogen since delayed maturity and excessive vegetative growth may result.

Lime — Lime should be applied to maintain the soil pH in the range 6.0 to 6.5.

Nitrogen — Nitrogen is best applied at the time of planting and broadcast at an appropriate level, since an excess will delay maturity of ripe tomatoes. If a side dressing is applied, apply only after fruit has developed on the second truss. Where plastic mulches are used the nitrogen application should be reduced since the nitrogen does not leach. Approximately 50 kg per hectare or less of nitrogen may be enough for vigorous cultivars on plastic mulch. Maturity may be delayed two to three weeks by an excessive application of nitrogen. Total yields of green plus ripe fruit are usually larger but early ripe yields are drastically reduced. For green chow tomatoes heavier rates of nitrogen should be used.

Phosphorus — It is most effectively used when banded at the time of transplanting especially when small quantities of fertilizer are being applied. Band at least 50 kg of phosphorus per hectare. Use a transplant solution if possible especially on low phosphorus soils.

Potash — broadcast potash requirements before planting and incorporate it into the soil along with the nitrogen.

Magnesium — on sandy soils low in organic matter and in magnesium content, foliar applications of epsom salts should be considered.

Calcium — on sandy soils low in calcium apply foliar sprays of calcium chloride to prevent blossom end rot.

Micronutrients *Boron* — Tomatoes have a high boron requirement. Apply a boronated fertilizer and apply at least one foliar spray of soluble boron.

Application Method — Nitrogen and potash should be broadcast prior to planting and incorporated into the soil. Phosphorus would be best banded and starter solutions should always be used. Fertilizer ratios of N to P to K of 1-2-1 have been the most effective on this crop. More fertilizer may be needed on staked cultivars.

Pests and Pest Control

Weeds

Control perennial weeds prior to planting. Many growers use black plastic mulch for weed control, especially when the crop is grown under plastic row tunnels. Most herbicides recommended for use on tomatoes will not provide complete control of annual weeds and supplemental cultivation is usually necessary.

Diseases

Damping Off (fungi)

Characteristics: Seed may decay, fail to emerge or once emerged develop water soaked discolored areas on the stem which withers and causes the plant to fall over. Disease incidence and severity is increased by cold temperatures, over watering, high humidity and over crowding.

Control: Hot water treat seed and apply a fungicide seed protectant. Plant seeds at the recommended rate into sterilized seeding mix and flats. Supply adequate moisture but do not overwater and maintain night temperatures above 16°C. Drench immediately after seeding with a fungicide and if damping off occurs continue to apply fungicides at weekly intervals.

Septoria Leaf Spot (fungus)

Characteristics: Causes numerous small grayish circular leaf spots with dark borders. Survives in crop residue and on seed. Wet weather favours disease development.

Control: Hot water treat seed. Apply protective fungicide sprays on a regular basis. Plow down crop residue immediately following harvest.

Early Blight (fungus)

Characteristics: Leaf spots are dark brown to black with concentric rings or zones within the spot. On fruit, large, dark, sunken areas develop particularly at the calyx end or on growth cracks.

Control: Apply fungicide sprays if required. Healthy plants which are not stressed can tolerate some leaf spotting.

Late Blight (fungus)

Characteristics: Irregular greenish black water soaked areas appear on older leaves. Infected fruit remains firm but becomes rough with greasy greenish-brown patches. This disease is more common under cool moist conditions and is the same fungus which causes late blight of potatoes.

Control: Apply fungicide sprays.

Anthracnose (fungus)

Characteristics: Common rot of ripe fruit causing circular sunken spots which develop dark centres. Infection by other secondary organisms may cause complete rotting of fruit. Fruit becomes more susceptible as it ripens.

Control: Apply fungicide sprays. Follow a 3 year rotation.

Botrytis Rot (fungus)

Characteristics: Gray mold rot of foliage, stem and fruit occurs. Pale green silvery ring marks with a brownish puncture in the center, known as ghost spot, occurs on the green fruit. The same rings are generally yellow on ripe fruit. This disease is associated with wet, humid weather.

Control: Use fungicides for control in tunnel house or field.

Bacterial Speck and Spot (bacterium)

Characteristics: These two bacterial diseases are spread by seed and transplants and can overwinter from the previous year's diseased crop. Most spread takes place during transplant production and is increased by high humidity. Symptoms include black spots on the leaves with a yellow border and small dark spots on the fruit.

Control: Hot water treat the seed and apply a fungicide seed protectant. Use sterilized soil in the greenhouse and disinfect flats. If these diseases appear in the greenhouse or field, apply appropriate fungicide plus copper sprays. Premixing the spray for 90 minutes or longer (overnight) increases efficacy. If tomatoes are staked use a disinfectant on used stakes. Follow at least a two year rotation.

Bacterial Canker (bacterium)

Characteristics: This bacterial disease is seed borne and can overwinter for one year in infected plant debris. Leaves wilt, die and brown cankers develop on the stem. White spots develop on the fruit with dark corky centers.

Control: Hot water treat the seed and apply a fungicide seed protectant. Use sterilized seeding mix and disinfect flats and tools. Do not plant into fields which have been infested for at least two years.

Virus Diseases

Tomato Mosaic: Leaves and occasionally green fruit are mottled with light and dark green patches. Fruit may ripen unevenly and have internal brown streaks. This highly infectious virus can be spread simply by touching infected plants.

Cucumber Mosaic: Infected plants are stunted with distorted (shoestring) leaves. Most disease spread is by aphids feeding first on diseased plants and then on healthy.

Double Virus Streak: This disease is caused by infection of the plant by both tomato mosaic and PVX virus. Infected plants have mottled leaves, brown streaks on the stems and petioles and brown greasy blotches on the fruit.

Control: Keep young plants virus-free by sanitation measures and aphid control. Avoid unnecessary handling of plants. Infections of older, well developed plants do not affect yield appreciably.

Grow seedlings away from mature tomato plants. Eradicate weed hosts in or near the greenhouse. Do not keep ornamentals in the same greenhouse with tomato seedlings. Do not smoke or chew tobacco when handling plants. Wash hands with soap (trisodium phosphate, a detergent, is best) and water before handling tomato plants. Do not harden transplants by leaving them in headlands or other weedy places. Do not use cultivators in an infected crop and then in a healthy one.

Non-Parasitic Disorders

Blossom-end Rot

A physiological disorder. Lack of adequate soil moisture and insufficient calcium uptake from the soil to the fruits during dry weather have been shown to cause this disorder. Excessive magnesium, potassium, sodium, or ammonium salts, or a deficiency of soluble calcium salts, all tend to decrease calcium uptake.

Control: Timely irrigation will reduce or prevent this disorder. If drought occurs, and irrigation is not possible, cultivation should be very shallow to reduce water loss. Hoeing or cultivating should be done no closer than 30 cm from the plants to avoid root pruning. Maintain a high organic matter content in the

soil and a high soil pH. A spray application of calcium chloride or calcium nitrate (or a trial preplant application of gypsum) may help control this disorder.

Blotchy Ripening

Characteristics: Blotchy Ripening is a disorder which involves irregular fruit ripening. Slow growth due to plant stress seems to be the cause.
Control: Eliminate heat or moisture stress wherever possible.

Yellow Shoulder

Characteristics: Climatic conditions prevent the red pigment from developing in the wall tissue near the stem. The shoulders of the tomato then became deep yellow in color. Cultivars with green shoulders are more susceptible and high temperatures during the growing season aggravate this problem. Fruits exposed to direct sunlight appear to be the most susceptible.
Control: Avoid susceptible cultivars and protect crops from high temperatures where possible.

Insects

Cutworm

Characteristics: Sometimes a serious problem especially near grassy margins of fields.
Control: Control couch grass and then perennial weeds in the year prior to planting. Apply chemical sprays as necessary.

Flea Beetles

Characteristics: Adults are 1.5 to 3 mm long, black or bronze beetles. Their hind legs are well developed for jumping. The white larvae are in the soil, and therefore seldom seen. Depending on species, there are one or two generations a year. Adults overwinter in the soil. Eggs are laid on or near the roots where larvae feed. Mature larvae pupate in the soil near the host plant. Adults emerge in early August for single-generation species. Last-generation adults feed on foliage until fall, when they return to the soil to overwinter.
Control: Before transplanting, lightly spray the plants in the flats with a field spray insecticide. Watch closely in the field as damage may occur suddenly and an insecticide may be needed.

Tomato Fruit Worm (Corn earworm)

Characteristics: This pest is usually not a serious problem. Larvae feed on the fruit. See Corn section for description.
Control: The insecticides applied for flea beetles will control this pest.

The Colorado Potato Beetle

Characteristics: The Colorado Potato Beetle is an occasional pest. Larvae feed on leaves.
Control: Insecticides applied for the flea beetle will control this pest.

SPECIFIC CHEMICAL CONTROLS FOR THE VARIOUS CROP PESTS DISCUSSED MAY BE FOUND IN THE SUPPLEMENT TO THIS GUIDE, A.P.A.S.C.C. PUBLICATION 1400A, "A GUIDE TO CULTIVAR SELECTION AND CHEMICAL PEST CONTROL FOR VEGETABLE CROPS."

Harvesting and Handling

Pick fruit at the ripe, pink or mature-green stage depending on its use and distance to market. At about 21°C, pink fruits ripen in 1 to 2 days and mature-green fruits in 4 to 5 days. Exposure of green fruit to ethylene supplied as a gas to harvested fruit, or as a field spray of ethephon, accelerates ripening. Prolonged exposure to temperatures above 30°C can inhibit red pigment formation.

Storage and Conditioning

Mature-green tomatoes should be stored at 13 to 21°C while firm ripe fruit can be held as low as 10°C (pink fruit are stored at intermediate temperatures, 10 - 15°C). Relative humidity in all cases should be 85-90%. Mature green fruit can be held 2-6 weeks while ripe fruit can only be held 1 week in conventional storage. Controlled atmosphere storage may be used to delay ripening and extend storage life. Botrytis and Alternaria rots may be a problem.

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X Vertebrate Pest Control

Losses due to vertebrate pest damage in the Atlantic area are serious. These pest problems are increasing due to factors such as the increasing deer population. Many growers believe there is nothing to be done other than to destroy the pest, but in many cases there are alternatives. Also, much research in proceeding on a world basis. The first step at remedying the situation is to discuss the biology of the pest with a Wildlife Biologist. In most cases only a combination of control measures will give effective results.

The following table suggests control measures for each pest. These pests are listed in their order of damage to vegetable crops:

Pest	**Usual Damage**	**Control Measures**
Deer	All vegetable crops except onions are consumed from trans-plants to harvested crops. Root crops may be pulled before consumption.	(1) Electric fencing — usually 100 percent effective with high voltage livestock fencing and equipment, Fences of 1 to 6 wires are used depending on local deer populations and whether fence is temporary or permanent. (2) High fences 2.4 M high. (Wire Mesh) (3) Chemical Repellents See Pub 1400 A. (4) Odor Repellents such as human hair, dog hair or blood meal may give some temporary control. (5) Visual Repellents eg. plastic bags on poles may give some temporary control. (6) Firearms eg. special harvest to reduce population; permit required usually. (7) Other (a) dogs chained to a perimeter wire (b) gas cannons or other noise makers (temporary control) (c) music — radios, etc.
Birds crows pheasants black birds starlings and others	— removal of seed — removal of seedlings — feeding on young plants — pecking crops from young plants to time of harvest — eg. sweet corn and squash	(1) Audio Scare Devices (a) gas cannons (exploders or bangers) (b) special firearms (cracker and whistler shells) (c) ultrasonic or electronic sounds (2) Visual Scare Devices (a) whirlers, streamers, spinners, reflectors, plastic hawks or owls. (b) scare crows (3) Netting (polyethylene, nylon, or cotton) (4) Trapping may be effective on an area basis. (5) Chemicals are not registered in Canada on food crops except as seed treatments and baits.

Raccoons	Primarily they damage sweet corn at or just before the picking stage. Corn ears are torn down and eaten with considerable knockdown of plants	(1) Electric fences are effective with wires located 12 and 25 cm above the soil. (2) Live trapping. (3) Hunting with dogs at night. (4) Dogs on a perimeter wire.
Moose	A serious problem in Newfoundland with many vegetable crops, particularly cabbage, turnips, and carrots.	(1) Fencing may be a difficult proposition, but high voltage, high tensile steel wire fencing, would be worth a trial (2) Gas Cannons have been used but only give temporary control. (3) Special harvest to reduce population; permit usually required.
Woodchucks	Usually only leafy crops are eaten but tomatoes and squash may also be attacked.	(1) Asphyxiation by carbon monoxide or other gases. (2) Traps (3) Firearms (4) Fencing (a) Chickenwire (b) electric 8 and 20 cm above soil surface.
Porcupine	Sweet corn close to maturity is tramped and torn down and cobs are eaten. Other crops such as cabbage can be occasionally attacked.	(1) Traps (2) Firearms (3) Fencing — similar to raccoon situation

In each province there are committees dealing with wildlife problems. These groups review vegetable grower concerns and complaints and needs for research, demonstrations and extension publications.

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XI APASCC Publications and General References

Atlantic Provinces Agricultural Services Coordinating Committee Publications

Vegetable Crops Guide to Cultivar Selection and Chemical Pest Control PUB # 1400A

Atlantic Canada Potato Guide PUB # 1300

Potato Crop Variety, Weed and Pest Control Recommendations PUB # 1300A

Field Crop Guide PUB # 100

Field Crop Guide to Variety and Pesticide Selection PUB # 100A

Soil Fertility Guide PUB # 535

Crop Micronutrients in Atlantic Canada PUB # 537

Winter Cereal Production PUB # 150

Soil Erosion PUB # 9

Atlantic Soils Need Lime PUB # 534

Soil and Fertilizer Nitrogen PUB # 536

Italian and Westerwolds Ryegrasses; Peformance, Management and Use PUB # 136

Farm Drainage in the Atlantic Provinces PUB # 3

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XII Measurement Conversion

Metric prefixes:

MILLI = one thousandth

CENTI = one hundredth

HECTO = one hundred

KILO = one thousand

It is now necessary to understand and use the metric system of measurement since all herbicides, fungicides, insecticides, and many other products are now manufactured and packaged with **only** metric measurements on the labels. To apply such products at the correct rate the grower should understand the metric system. Applying products at the correct rate is important because a spray underdose will not control pests, while an overdose will increase cost of application and may damage or cause high residue levels in the plants. To avoid confusion and mistakes, it is strongly recommended that growers switch completely to the metric system and not use the Imperial (British) system at all. For methods of calibrating sprayers, see your agricultural representative. This calibration should be done at least once a year since nozzle wear and other factors alter the output. Tools for measuring volume, length, and weight in metric units will be needed. Some devices in Imperial units, e.g. Fahrenheit thermometers, may be converted to the metric system with the aid of a permanent marking pen and tables given later in this guide. The first two tables below should be read line-by-line as an introduction to the metric units to learn their approximate sizes and abbreviations.

INTRODUCTION TO IMPORTANT METRIC UNITS

cm	=	centimetre = one hundredth of a metre = 0.3937 inches
g	=	gram = one thousandth of a kilogram = approximately the weight of one regular cigarette
h	=	hour
ha	=	hectare = 10,000 square metres = 2.471 acres
kg	=	kilogram = 1000 grams = weight of 1 litre of water = 2.2 pounds
kg/ha	=	kilograms per hectare = 0.89 lbs/acre
km	=	kilometre = 1000 metres = 0.621 miles
kPa	=	kilopascal (221 kPa = 32 psi (pressure)
kW	=	kilowatt = 1000 watts
L	=	l = litre = 1000 millilitres = 0.22 gallons
m	=	metre = 100 centimetres = 1.094 yards
m^2	=	square metre = 1.2 square yards
m^3	=	cubic metre = 1.31 cubic yards
mhp	=	metric horsepower = 1.0 British horsepower
mL	=	ml = millilitre = one thousandth of a litre = fifth of a teaspoon
mm	=	millimetre = one tenth of a centimetre
min	=	minute
q	=	quintal = 100 kg = 220 lb
s	=	second
t	=	tonne = metric tonne = 1000 kilograms = 1.1 short tons

METRIC TO METRIC EQUIVALENTS

Example: To convert 33,500 grams to kilograms:
33,500 g × (1 kg/1000 g) = 33.5 kg

AREA	1 ha = 10,000 m^2 = 0.01 km^2
	1 m^2 = 10,000 cm^2
LENGTH	1 cm = 0.01 m = 10mm
	1 km = 1000 m
	1 m = 100 cm = 1000 mm = 0.001 km
	1 mm = 0.1 cm = 0.001 m
POWER	1kW = 1000 watts = 1.35 mhp
PRESSURE	1 kPa = 10 g/cm^2 = 100 kg/m^2
SPEED	1 km/h = 0.278 m/s = 27.8 cm/s
	1 m/s = 100 cm/s = 3.6 km/ha = 60 m/min
RATE	1 kg/ha = 0.001 t/ha = 0.1 g/m^2
	1 t/ha = 1000 kg/ha = 100 g/m^2
VOLUME	1 cm^3 = 1 cc = 1 mL
	1 L = 1000 mL = 1000 cm^3 = 0.001 m^3
	1 m^3 = 1000 L
	1 mL = 1 cm^3 = 0.001 L
WEIGHT	1 g = 0.001 kg
	1 kg = 1000 g = 0.001 t
	1 q = 100 kg = 0.1 t
	1 t = 1000 kg

IMPERIAL TO METRIC

Example: To convert 20 acres to hectares:
20 acres × 0.4047 = **8.1** ha

TO CONVERT FROM	MULTIPLY BY	RESULTS IN
AREA		
____acres	× 0.4047	= ____ha
____sq ft	× 0.0929	= ____m^2
____sq in.	× 6.452	= ____cm
____sq mi	× 2.59	= ____km^2
____sq mi	× 259	= ____ha
____sq yd	× 0.8361	= ____m^2
LENGTH		
____ft	× 30.48	= ____cm
____ft	× 0.305	= ____m
____in.	× 2.54	= ____cm
____in.	× 25.400	= ____mm
____mi	× 1.61	= ____km
____yd	× 0.9144	= ____m
POWER		
____Bhp	× 1.01	= ____mph
____Bhp	× 746	= ____W
____ft lb	× 0.138	= ____kgm
PRESSURE		
____bar	× 100	= ____kPa
____psi	× 6.9	= ____kPa
____psi	× 0.0704	= ____kg/cm^2
SPEED, FLOW		
____fps	× 0.30	= ____m/s
____gpm	× 4.55	= ____L/min
____mph	× 1.609	= ____km/h
____mph	× 0.447	= ____m/s
____rpm	× 1	= ____Rev/min

TEMPERATURE
Take temperature in Fahrenheit, subtract 32, then multiply by 5, and then divide by 9 to get Celsius.

VOLUME		
____bd ft	× 0.00236	= ____m^2
____bu (8 gal Cdn)	× 36.37	= ____L
____cu ft.	× 0.0283	= ____m^3
____cu in.	× 16.39	= ____cm^3 = cc
____cu yd	× 0.765	= ____m^3
____fl oz	× 28.41	= ____mL
____gal	× 4.546	= ____L
____pt	× 0.568	= ____L
____qt	× 1.136	= ____L
____tbsp	× 15	= ____mL
____tsp	× 5	= ____mL
WEIGHT		
____oz	× 28.35	= ____g
____lb	× 0.454	= ____kg
____short tons	× 0.91	= ____t
YIELD OR RATE		
____bu/acre	× 89.8	= ____L/ha
____fl oz/acre	× 70.21	= ____mL/ha
____gal/acre	× 11.23	= ____L/ha
____gal/100 gal	× 1	= ____L/100L
____gal/1000 sq ft	× 4.89	= ____$L/100M^2$
____oz/acre	× 70	= ____g/ha
____oz/bu (50 lb)	× 25.0	= ____g/20 kg
____oz/1000 cu ft	× 100	= ____$g/100\ m^3$
____oz/100 ft of row	× 93	= ____g/100 m
____oz/gal	× 6.25	= ____g/L
____oz/10 gal	× 62.5	= ____g/100 L
____oz/100 gal	× 62.5	= ____g/1000 L
____oz/ sq ft	× 305	= ____g/m^2
____oz/1000 sq ft	× 30.5	= ____$g/100\ m^2$
____pt/acre	× 1.41	= ____L/ha
____pt/100 gal	× 1.25	= ____L/1000 L
____pt/1000 sq ft	× 0.61	= ____$L/100\ m^2$ L
____pounds/acre	× 1.12	= ____kg/ha
____pounds/1000 cu ft	× 1.6	= ____$kg/100\ m^3$
____pounds/100 ft row	× 1.5	= ____kg/100 m
____pounds/100 gal	× 1	= ____kg/1000 L
____pounds/1000 sq ft	× 488	= ____$g/100\ m^2$
____pounds/sq yd	× 543	= ____g/m^2
____plants/acre	× 2.47	= ____plants/ha
____qt/acre	× 2.81	= ____L/ha

METRIC TO IMPERIAL

Example: To convert 645 sq. cm to square inches:
645 cm^2 × 0.155 = **100** sq. in

TO CONVERT FROM	MULTIPLY BY	RESULTS IN:
AREA		
____cm^2	× 0.155	= ____sq. in.
____ha	× 2.471	= ____acres
____km^2	× 247	= ____acres
____km^2	× 0.386	= ____sq mi
____m^2	× 10.76	= ____sq ft
____m^2	× 1.196	= ____sq yd
LENGTH		
____cm	× 0.3937	= ____in.
____cm	× 0.03281	= ____ft
____km	× 0.6214	= ____mi
____m	× 3.281	= ____ft
____m	× 1.094	= ____yd
____mm	× 0.03937	= ____in.
POWER		
____kgm	× 7.233	= ____ft lb
____kW	× 1.34	= ____Bhp
____mhp	× 0.99	= ____Bhp
PRESSURE		
____kg/cm^2	× 14.22	= ____psi
____kPa	× 0.145	= ____psi
____kPa	× 0.01	= ____bar
SPEED, FLOW		
____km/h	× 0.621	= ____mph
____L/min	× 0.22	= ____gpm
____m/s	× 196.9	= ____fpm
____m/s	× 2.237	= ____mph
____Rev/min	× 1	= ____rpm

TEMPERATURE

Take temperature in degrees Celsius, multiply by 1.8, and then add 32 to get degrees Fahrenheit.

VOLUME

____cm^3	× 0.061	=	____cu in.
____L	× 0.88	=	____qt
____L	× 0.22	=	____gal
____m^3	× 1.308	=	____cu yd
____mL	× 0.2	=	____tsp
____mL	× 0.067	=	____tbsp
____mL	× 0.035	=	____fl oz

WEIGHT

____g	× 0.035	=	____oz
____kg	× 2.2	=	____lb
____q	× 220	=	____lb
____t	× 1.1	=	____short tons

YIELD OR RATE

____g/ha	× 0.0143	=	____oz/acre
____$g/100m^2$	× 0.0328	=	____oz/1000sq ft
____g/100m row	× 0.0108	=	____oz/100ft
____$g/100m^3$	× 0.01	=	____oz/1000cu ft
____g/20kg seed	× 0.04	=	____oz/bu (oz per 50 lb seed)
____g/L	× 0.160	=	____oz/gal
____g/100L	× 0.016	=	____oz/10 gal
____g/1000L	× 0.016	=	____oz/100 gal
____kg/ha	× 0.8922	=	____lb/acre
____kg/100 m row	× 0.672	=	____lb/100 ft
____$kg/100m^3$	× 0.625	=	____lb/1000 cu ft
____kg/1000 L	× 1	=	____lb/100 gal
____L/ha	× 0.089	=	____gal/acre
____$L/100\ m^2$	× 1.64	=	____pt/1000 sq ft
____L/100 L	× 1	=	____gal/100gal
____L/1000 L	× 0.8	=	____pt/100 gal
____mL/ha	× 0.0142	=	____fl oz/acre
____plants/ha	× 0.405	=	____plants/acre

The following tables may be used to convert pounds, gallons, acres, gallons/acre, pounds/acre, and degrees Fahrenheit to the metric system without calculations. The final table gives plants/hectare at various plant spacings, to assist in planning transplant production, etc.

Pounds Converted to Kilograms

Example: To change 50 lb into kg look at the row beside 50 and the column under 0 and read 22.7 kg.

lb	0	1	2	3	4	5	6	7	8	9
0	kg	0.5	0.9	1.4	1.8	2.3	2.7	3.2	3.6	4.0
10	4.5	5	5	6	6	6.8	7	8	8	9
20	9.1	10	10	10	11	11.3	12	12	13	13
30	13.6	14	15	15	15	15.9	16	17	17	18
40	18.1	19	19	20	20	20.4	21	21	22	22
50	22.7	23	24	24	24	24.9	25	26	26	27
60	27.2	28	28	29	29	29.5	30	30	31	31
70	31.8	32	33	33	34	34.0	34	35	35	36
80	36.3	37	37	38	38	38.6	39	39	40	40
90	40.8	41	42	42	43	43.1	44	44	44	45

Pounds/Acre Converted to Kilograms/Hectare

Example: To change 32 lb/acre into kg/ha look at the row beside 30 and the column under 2 and read 36 kg/ha.

lb/ acre	0	1	2	3	4	5	6	7	8	9
0	kg/ha	1.1	2.2	3.4	4.5	5.6	6.7	7.9	9.0	10
10	11	12	13	15	16	17	18	19	20	21
20	22	24	25	26	27	28	29	30	31	33
30	34	35	36	37	38	39	40	41	43	44
40	45	46	47	48	49	50	52	53	54	55
50	56	57	58	59	61	62	63	64	65	66
60	67	68	70	71	72	73	74	75	76	77
70	78	80	81	82	83	84	85	86	87	89
80	90	91	92	93	94	95	96	98	99	100
90	101	102	103	104	105	107	108	109	110	111
100	112									

Degrees Fahrenheit Converted to Degrees Celsius

Example: To change 41°F to C, look at the row beside 40 and the column under 1 and read 5.0 C.

Fahrenheit	0	1	2	3	4	5	6	7	8	9
0	−17.8	−17.2	−16.7	−16.1	−15.6	−15.0	−14.4	−13.9	−13.3	−12.8
10	−12.2	−11.7	−11.1	−10.6	−10.0	− 9.4	− 8.9	− 8.3	− 7.8	− 7.2
20	− 6.7	− 6.1	− 5.6	− 5.0	− 4.4	− 3.9	− 3.3	− 2.8	− 2.2	− 1.7
30	− 1.1	− 0.6	0	+ 0.6	+ 1.1	+ 1.7	+ 2.2	+ 2.8	+ 3.3	+ 3.9
40	4.4	5.0	5.6	6.1	6.7	7.2	7.8	8.3	8.9	9.4
50	10.0	10.6	11.1	11.7	12.2	12.8	13.3	13.9	14.4	15.0
60	15.6	16.1	16.7	17.2	17.8	18.3	18.9	19.4	20.0	20.6
70	21.1	21.7	22.2	22.8	23.3	23.9	24.4	25.0	25.6	26.1
80	26.7	27.2	27.8	28.3	28.9	29.4	30.0	30.6	31.1	31.7
90	32.2	32.8	33.3	33.9	34.4	35.0	35.6	36.1	36.7	37.2
100	37.8	38.3	38.9	39.4	40.0	40.6	41.1	41.7	42.2	42.8
110	43.3	43.9	44.4	45.0	45.6	46.1	46.7	47.2	47.8	48.3
120	48.9	49.4	50.0	50.6	51.1	51.7	52.2	52.8	53.3	53.9
130	54.4	55.0	55.6	56.1	56.7	57.2	57.8	58.3	58.9	59.4
140	60.6	60.0	61.1	61.7	62.2	62.8	63.3	63.9	64.4	65.0
150	65.6	66.1	66.7	67.2	67.8	68.3	68.9	69.4	70.0	70.6
160	71.1	71.7	72.2	72.8	73.3	73.9	74.4	75.0	75.6	76.1
170	76.7	77.2	77.8	78.3	78.9	79.4	80.0	80.6	81.1	81.7
180	82.2	82.8	83.3	83.9	84.4	85.0	85.6	86.1	86.7	87.2
190	87.8	88.3	88.9	89.4	90.0	90.6	91.1	91.7	92.2	92.8
200	93.3	93.9	94.4	95.0	95.6	96.1	96.7	97.2	97.8	98.3
210	98.9	99.4	100.0							

Gallons Converted to Litres

Example: To change 75 gals to L, look at the row beside 70 and the column under 5 and read 341 L.

gal	0	1	2	3	4	5	6	7	8	9
0	litres	4.6	9.1	14	18	23	27	32	36	41
10	45	50	55	59	64	68	73	77	82	86
20	91	95	100	105	109	114	118	123	127	132
30	136	141	145	150	155	159	164	168	173	177
40	182	186	191	195	200	205	209	214	218	223
50	227	232	236	241	245	250	255	259	264	268
60	273	277	282	286	291	295	300	305	309	314
70	318	323	327	332	336	341	345	350	355	359
80	364	368	373	377	382	386	391	395	400	405
90	409	414	418	423	427	432	436	401	446	450

Acres Converted to Hectares

Example: To change 23 acres into hectares look at the row beside 20 and the column under 3 and read 9.3 hectares.

acres	0	1	2	3	4	5	6	7	8	9
0	ha	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6
10	4.0	4.5	4.9	5.3	5.7	6.1	6.5	6.9	7.3	7.7
20	8.1	8.5	8.9	9.3	9.7	10.1	10.5	10.9	11.3	11.7
30	12.1	12.5	13.0	13.4	13.8	14.2	14.6	15.0	15.4	15.8
40	16.2	16.5	17.0	17.4	17.8	18.2	18.6	19.0	19.4	19.8
50	20.2	20.6	21.0	21.4	21.9	22.3	22.7	23.1	23.5	23.9
60	24.3	24.7	25.1	25.5	25.9	26.3	26.7	27.1	27.5	27.9
70	28.3	28.7	29.1	29.5	29.9	30.4	30.8	31.2	31.6	32.0
80	32.4	32.8	33.2	33.6	34.0	34.4	34.8	35.2	35.6	36.0
90	36.4	36.8	37.2	37.6	38.0	38.4	38.8	39.3	39.7	40.0

Gallons/Acre Converted to Litres/Hectare

Example: To change 45 gal/acre to L/ha look at the row beside 40 and the column under 5 and read 505 L/ha.

Gal/ acre	0	1	2	3	4	5	6	7	8	9
0	L/ha	11	22	34	45	56	67	79	90	101
10	112	124	135	146	157	168	180	191	202	213
20	225	236	247	258	270	281	292	303	314	326
30	337	348	359	371	382	393	404	416	427	438
40	449	461	472	483	494	505	517	528	539	550
50	562	573	584	595	607	618	625	640	651	663
60	674	685	696	708	719	730	741	753	763	775
70	786	797	809	820	831	842	854	865	876	887
80	899	910	921	932	943	955	966	977	988	1.000
90	1,011	1,022	1,033	1,045	1,056	1,067	1,078	1,089	1,101	1,112
100	1,123									

Number of Plants/Hectare at Various Spacings

Spacing in centimetres	No. of plants	Spacing in centimetres	No. of plants	Spacing in centimetres	No. of plants
25 × 2	2,000,000	75 × 50	26,666	125 × 60	13,333
25 × 5	800,000	75 × 60	22,222	125 × 75	10,400
25 × 10	400,000	75 × 75	17,777	125 × 80	10,000
25 × 15	266,666			125 × 90	8,888
25 × 20	200,000	100 × 2	500,000	125 × 100	8,000
25 × 25	160,000	100 × 5	200,000	125 × 125	6,400
		100 × 10	100,000		
50 × 2	1,000,000	100 × 15	66,666	150 × 5	133,333
50 × 5	400,000	100 × 20	50,000	150 × 10	66,666
50 × 10	200,000	100 × 25	40,000	150 × 25	26,666
50 × 15	133,333	100 × 30	33,333	150 × 50	13,333
50 × 20	100,000	100 × 40	25,000	150 × 75	8,888
50 × 25	80,000	100 × 50	20,000	150 × 100	6,666
50 × 30	66,666	100 × 60	16,666	150 × 125	5,200
50 × 35	57,142	100 × 75	13,333	150 × 150	4,444
50 × 40	50,000	100 × 80	12,500		
50 × 45	44,444	100 × 90	11,111	175 × 5	114,280
50 × 50	40,000	100 × 100	10,000	175 × 10	57,140
				175 × 25	22,856
75 × 2	666,666	125 × 2	400,000	175 × 50	11,428
75 × 5	266,666	125 × 5	160,000	175 × 75	7,618
75 × 10	133,333	125 × 10	80,000	175 × 100	5,714
75 × 15	88,888	125 × 20	40,000	175 × 125	4,571
75 × 20	66,666	125 × 25	32,000	175 × 150	3,809
75 × 25	53,333	125 × 30	26,666	175 × 175	3,265
75 × 30	44,444	125 × 40	20,000		
75 × 40	33,330	125 × 50	16,000		

Vegetable Extension Specialists

Newfoundland Dept. of Rural, Agricultural & Northern Development

Crop Specialist
Box 340
Pasadena A0L 1K0
Tel: 709-686-2546

Crop Specialist
Provincial Agriculture Building
PO Box 4750
St. John's, Nfld.
Tel: 709-737-2639

Crop Specialist
PO Box 640
Bishop Falls A0H 1C0
Tel: 709-258-5334

Nfld. Crop Insurance Agency
Prov. Agriculture Building,
St. John's, Nfld.
A1C 5P7
Tel: 709-576-3843

Nova Scotia Dept. of Agriculture and Marketing

Plant Pathologist
Agricultural Centre
Kentville B4N 1J5
Tel: 902-678-7365

Entomologist
NSAC
Truro B2N 5E3
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Vegetable Specialist
Agricultural Centre
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Weed Control Specialist
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Marketing Specialist Horticultural Crops
Agricultural Centre
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Farm Machinery Specialist
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Veg. Storage & Energy Specialist
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Greenhouse Specialist
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Nova Scotia Crop Insurance Commission
640 Prince St.
Box 1092 Truro B2N 5G9
Tel: 902-895-4431

New Brunswick Dept. of Agriculture and Rural Development

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Plant Pathologist
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Soils Specialist
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Weed Control Specialist
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Director of Market Development
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Prince Edward Island Dept. of Agriculture and Forestry

Farm Machinery Specialist
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Buildings Engineer
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Plant Pathologist
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Tel: 902-368-5629

Crops Mkg Supervisor
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Crops Supervisor
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Charlottetown C1A 7N3
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Vegetable Specialist
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PEI Crop Insurance Commission
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Charlottetown C1A 7N8
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